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MODERN CYCLES

A Practical Handbook

ON

THEIR CONSTRUCTION AND REPAIR

BY

A. J. WALLIS-TAYLER, C.E.

ASSOC. MEMB. INST. C.E.

AUTHOR OF "REFRIGERATING AND ICE-MAKING MACHINERY," "SUGAR MACHINERY," "BEARINGS AND LUBRICATION," ETC. ETC.

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PREFACE.

THE construction of cycles has now been brought to such a degree of perfection as to render a book dealing with the subject less ephemeral in character than would have been the case a few years ago. The present almost universal use of cycles, moreover, has increased a hundred-fold the interest in, and the want of, such a work.

As far back as 1886 the President of the Institution of Mechanical Engineers, when closing the discussion upon papers read upon this subject, remarked that "bicycles and tricycles were now everywhere so plentiful that they were sometimes voted a nuisance, and thought unworthy of recognition by dignified engineers. But he was sure that those who had heard the papers, and especially those who had enjoyed the advantage of going over the makers' works at Coventry, must have felt that these

machines were very well worthy of attention, and had come to be a most important feature in modern civilisation."

The ten years which have elapsed since these observations were made have brought about the perfection of the "rear-driving safety" cycle, then just introduced, and the re-invention and practically universal application of pneumatic tyres; and the manufacture of cycles may now truly be said to have attained to an importance which renders it a subject of interest to all engineers, and not merely to those connected with the production of the machines.

Every year numerous improvements are made in the various parts of cycles, or in accessories thereto, by persons who usually desire to secure protection for their ideas, and to reap all possible advantage therefrom. To render the present work valuable to this class of readers, short abridgments of some of the most interesting patents relating to each part of cycle construction are given; and it is hoped that this feature of the book, by showing something of what has been already done in particular directions, will assist inventors in judging as to the novelty, or

otherwise, of their improvements, and as to whether or not they are worth procceding with, before expending perhaps a considerable amount of time and money.

When it is considered that the factor of safety allowed in cycles is only $1\frac{1}{2}$ as against 4 to 10 in ordinary machinery, it will be readily seen, with this small margin, how important it is that all riders should be acquainted with the weak points in the machines they use, and be able to make a tolerably accurate estimate of the strains to which they may be safely subjected, thereby avoiding possibly dangerous accidents. Consequently, a book of this description appeals also to all cycle riders, now a very numerous class, every one of whom should know the why and the wherefore of the various truths and facts which he learns by experience with his machine.

The subject of repairs and renewals, which has been dealt with in a separate chapter, and as fully as the space at command would admit of, should also prove of service to many riders, who, having the necessary mechanical ability and the requisite tools and appliances at command, may desire to undertake for themselves the execution of such work.

The purely theoretical aspect of the subject, which would necessitate treating of geometry, kinematics, dynamics, mechanics, &c., has been avoided as much as possible. Those in want of information can obtain ample store in the many excellent works upon these sciences already published; and the insertion, in a book of this description, of an elementary treatise on the principles of mechanics would only tend to swell the work to undue proportions, and to necessitate the exclusion of useful matter.

A. J. WALLIS-TAYLER.

323 HIGH HOLBORN, LONDON, W.C.,
December 1896.

TABLE OF CONTENTS.

CHAPTER I.—INTRODUCTION.

PAGE

Brief History of the Cycle 1

CHAPTER II.—MODERN SAFETY BICYCLES OR DICYCLES.

Roadsters—Racers—Machines adapted for Ladies' Use—Bicycles or Dicycles for Two or More Riders—Tandem Bicycles—Triplets, Quadruplets, &c.—Sociable Bicycles or Dicycles—Convertibles 11

CHAPTER III.—MODERN TRICYCLES OR THREE-WHEELED CYCLES.

Tandem Tricycles—Sociable Tricycles. 36

CHAPTER IV.—CARRIERS.

Passenger Carriers - Goods Carriers 47

CHAPTER V.—MISCELLANEOUS MACHINES.

Quadricycles or Tetracycles—Multicycles—Unicycles or Monocycles—Manumotive or Hand-power Velocipedes—Ice Velocipedes—Water Cycles 52

CHAPTER VI.—EFFICIENCY OF CYCLES.

Distribution of Wheel Load in Bicycles—Efficiency of Three-wheeled Cycles or Tricycles—Adjustment—Momentum of Cycle and Rider—Power consumed in Driving. DYNAMICS. STATICS—Weight Distribution—Compression of Tyres—Centre of Gravity—Strength of Parts. KINEMATICS—Traction—Pressure on Pedal—Work Done—Energy of Motion—Vibration—Economic Considerations . . 61

PAGE

CHAPTER VII.—COMPONENT PARTS OF CYCLES.

The Framework. WHEELS—Hubs—Rims—Spokes—Spring Wheels—Disc Wheels—Spring Tyres—Pneumatic Tyres and Valves. THE STEERING—Steering Heads—Handle-bars—Forks. DRIVING GEAR — Chain-driving Gear — Driving Bands—Cam Gear—Crank Gear—Toothed Gear. VARIABLE SPEED GEAR — Epicyclic Gear — Variable Throw Cranks—Change Wheels—Expanding Chain or Sprocket Wheels—Double Sets of Chain Gearings, &c.—Reciprocating Cranks—Crank Arms—Pedals—Saddles or Seats—Brakes—Fittings and Accessories . . . 79

CHAPTER VIII.—THE MANUFACTURE OF CYCLES.

Framework—Wheels—Driving Gear—Enamelling. NICKEL-PLATING—Polishing—Baths—The Plating Tank or Vat—Electric Current—Preliminary Preparation—Treatment of Different Metals—Stripping and Replating—General Observations 246

CHAPTER IX.—REPAIRS AND RENEWALS.

Frames, &c.—Wheels—Machined Work—Tyres . . 278

APPENDIX.

Verbatim Copy of Thomson's Specification, No. 10,990, 1845, or Carriage Wheels (the First Patent for a Pneumatic or Air Tyre) 316

INDEX 321

LIST OF ILLUSTRATIONS.

FIG.		PAGE
1.	Dandy or Hobby-horse	4
2.	"Bone-shaker"	5
3.	"Ordinary" or High Bicycle	7
4.	The "Club" Safety Bicycle	8
5.	Humber Roadster Safety	13
6.	Starley Brothers' Roadster Safety	14
7.	Premier Cycle Co. Ltd. Roadster Safety	15
8.	Sparkbrook Manufacturing Co. Ltd. Roadster Safety	16
9.	Drzewiecki "Cyclet" Roadster Safety	17
10.	Crypto Works Co. Ltd. "Bantam" Roadster Safety	20
11.	Humber Lady's Safety	23
12.	Starley Brothers' Lady's Safety	24
13.	Premier Cycle Co. Ltd. Lady's Safety	25
14.	Sparkbrook Manufacturing Co. Ltd. Lady's Safety	26
15.	Humber & Co. Ltd. Tandem	28
16.	Humber & Co. Ltd. Open-Fronted Tandem	29
17.	Humber & Co. Ltd. Tandem Racer	30
18.	Humber & Co. Ltd. Triplet	31
19.	Punnett Sociable Single-track Bicycle or Dicycle	32
20.	Starley Brothers' Gentleman's Tricycle	39
21.	Humber & Co. Ltd. Gentleman's Tricyle	40
22.	Sparkbrook Manufacturing Co. Ltd. Gentleman's Tricycle	41
23.	Marriott & Cooper Gentleman's Tricycle	42
24.	Marriott & Cooper Tandem Tricycle	44
25.	Singer & Co. Ltd. Front-driver Parcel-Carrying Machine	51
26.	Monocycle or Unicycle	54

FIG.		PAGE
27.	Sociable Monocycle or Unicycle	55
28.	Singer Manumotive or Hand-power Velocipede	58
29.	Diagram showing Distribution of Wheel Load in "Ordinary"	64
30.	Diagram showing Distribution of Wheel Load in "Club" Safety	65
31.	Diagram showing Distribution of Wheel Load in "Xtra-ordinary" Safety	65
32.	Diagram showing Distribution of Wheel Load in "Bantam" Safety	66
33.	Diagram showing Distribution of Wheel Load in "Cyclet" Safety	67
34.	Diagram showing Distribution of Wheel Load in Rear-Driving Chain Safety	68
35.	Standard Pattern Bicycle Frame	79
36.	Premier Co. Helical Tube	80
37.	Fowler Truss Frame	84
38.	Method of forming Joints in Frames without Brazing	85
39.	Dover's Method of forming Joints in Bamboo Frames	88
40.	M'Anney's Method of forming Joints in Bamboo Frames	89
41.	Diagram showing Construction of Typical Ball Bearing	95
42, 43.	Æolus Ball Bearings	97
44.	Premier Cycle Co. Hub	98
45.	Rudge-Whitworth Ltd. Hub	99
46.	Barrel or Disc-adjusting Hub	100
47.	Humber Dust-proof and Oil-retaining Hub	101
48.	Preston Davies Adjustable Hub	102
50.	Perry & Co. Ltd. Elongated Dust-proof Hub	104
51.	Harry James Adjustable Hub	104
52.	Kotin-Tayler Roller Hub	105
53-57.	Warwick Hollow Metallic Rims or Felloes	107, 108
58.	Westwood-Butler Hollow Metallic Rim or Felloe	108
59.	Westwood Metallic Rim	109
60, 61.	Sparkbrook Hollow Metallic Rim or Felloe	109, 110
62.	James Hollow Detachable Rim	110
63.	James Hollow Continental Rim	110
64.	James Inside Bead Rim	110
65.	James Single Rim	111
66.	Boston Laminated Wood Rim	111
67.	Hurndall Laminated Wood Rim	111
68-72.	Various Patterns of Wire Spokes	112
74.	Disc Wheel (Side View)	115

FIG. PAGE
75. Disc Wheel (Trans. Sect.) 116
76. Wallis-Tayler Spring Tyre 117
77–79. Honrath Spring Tyres 118
80. Dunlop Pneumatic or Air Tyre 120
81. Dunlop Pneumatic Valve 120
82. Boothroyd Roadster Single-Tube Pneumatic Tyre . . 121
83. Morgan & Wright Single-Tube Pneumatic Tyre . . 121
84. Welch Built-up, Wire-attached Pneumatic Tyre (Early Form) 122
85. Welch Built-up, Wire-attached Pneumatic Tyre (Modern Form) 123
86. Beeston Built-up, Wire attached, Corrugated Pneumatic Tyre 124
86*a*. Beeston Built-up, Wire-attached "Oat" Pneumatic Tyre . 124
87. Woodley Built-up, Wire-attached Pneumatic Tyre . . 125
87*a*. Bartlett ("Clincher") Wedge-action, Built-up Pneumatic Tyre (Early Form) 126
88. Bartlett ("Clincher") Wedge-action, Built-up Pneumatic Tyre (Later Form) 127
89. Scott Built-up, Wedge-action Pneumatic Tyre . . 127
90. Palmer Built-up, Wedge-action Pneumatic Tyre . . 128
91. Shaw-Boothroyd-Sydenham Built-up, Wedge-action Pneumatic Tyre 128
92. Palmer Built-up, Wedge-action Pneumatic Tyre . . 129
93, 94. Gormully & Jeffery Built-up, Wedge-action Pneumatic Tyre 129, 130
95–97. Gormully & Jeffery Pneumatic Valve . . . 131
98, 99. Bowley Built-up, Wedge-action Pneumatic Tyres 132, 133
100. Mongiardino-Davies Tubeless, Wedge-action Pneumatic Tyre 133
101–106. Lungren Tubeless, Wedge-action Pneumatic Tyres 134, 136, 137
107. Fleuss Tubeless, Wedge-action Pneumatic Tyre (Inflated) . 137
108. Fleuss Tubeless, Wedge-action Pneumatic Tyre (Detached) 138
109. Self-healing Pneumatic Tyre 139
110. Puncture-Proof Company's Speedifier Band . . 139
111, 112. Palmer Puncture-proof Pneumatic Tyre . . 140
113. Palmer Puncture-proof Air Tube 141
114. Lazerges Self-healing Pneumatic Tyre . . . 141
115–117. Stuart Unpuncturable Pneumatic Tyre . . 142
118. Fleuss Protected Tread 143
119. Rudge-Whitworth Steering or Ball-head Adjustment . 148
120. Rudge-Whitworth Ball Steering Head . . . 149

FIG.		PAGE
121.	Humber Ball Steering Head	150
122.	Singer Ball Steering Head and Steering Lock	151
123.	Perry Ball Steering Head	152
124.	Triple Steering Head	152
125.	Flat Roadster Handle-bar	154
126.	Flat Road Racer Handle-bar	154
127.	Semi-drop Handle-bar	154
128.	Scorcher Drop Handle-bar	154
129.	Path Racer Drop Handle-bar	155
130.	Forward Racer Handle-bar	155
131.	Raised Pattern Handle-bar	155
132.	Patent Adjustable or Swinging Handle-bar	155
133.	Anti-vibrating Handle or Grip	157
134.	Detachable Cork Handle or Grip	157
135.	Fork Strengthener	158
136.	Unbreakable Fork (Side View)	159
137.	Unbreakable Fork (Horizontal Section)	160
138.	Morgan Driving or Pitch Chain	161
139.	Starley Detachable Link Pitch Chain	161
140.	Abingdon Single Link Pitch Chain	161
141.	Perry-Humber Pattern Pitch Chain	162
142.	Appleby-Humber Twin Roller Pitch Chain	162
143.	Appleby-Osmond Dwarf Roller Pitch Chain	162
144, 145.	Crank Driving Gears and Bottom Brackets	163, 164
146.	Bottom Bracket Bridge Piece	165
147.	Driving Wheel Hub and Sprocket	165
148.	Driving Wheel Sprocket or Chain Wheel	166
149, 150.	Fork Ends and Chain Adjustment	166
151.	Tricycle Crank or Bottom Bracket	167
152, 153.	Humber Pattern Sprocket or Chain Wheel	168
154.	Rudge-Whitworth Crank Bracket	169
155.	Rudge-Whitworth Interchangeable Gear	170
156.	Rudge-Whitworth Rear Chain Adjustment	170
157.	Singer Detachable Crank Bearing	171
158, 159.	Humber Crank or Bottom Bracket	171
160, 161.	Humber Tandem or Triplet Swing Adjusting Bottom Bracket	172
162.	Humber Patent Swing Chain Adjustment	173
163.	Humber Tricycle Swing Chain Adjustment	174
164.	Humber Detachable Crank and Gear Wheel	176
165.	Preston Davies Bottom Bracket Bearing	177

FIG. PAGE
166. Simpson Lever Chain and Sprocket or Chain Wheel . 178
167. Diagram showing Transmission of Power by an Ordinary Block Chain 179
168. Diagram showing Transmission of Power by a Simpson Lever Chain 179
169. View showing Wear of Teeth of Driving Chain or Sprocket Wheel 180
170. View showing Wear of Teeth of Driven Chain or Sprocket Wheel 181
171. View showing Wear of Pitch Chain . . . 182
172. Lock Patent Ball Tooth Chain Gearing . . . 183
173. Lock Patent Method of Mounting Ball or Spherical Teeth 183
174, 175. Lock Patent Pitch Chain 183
176. Preston Davies Patent Ball Tooth Chain Gearing . . 184
177. Modified Arrangement of Preston Davies Patent Ball Tooth Chain Gearing (Plan) 185
178. Modified Arrangement of Preston Davies Patent Ball Tooth Chain Gearing (Side View) 185
179, 180. Kotin Patent Ball Tooth Chain Gearing . 186, 187
181. Kotin Patent Improved Pitch Chain (Plan) . . 187
182. Kotin Patent Improved Pitch Chain (Underside View) . 187
183. Modified Form of Kotin Patent Improved Pitch Chain . 188
184. Modified Form of Kotin Patent Ball Tooth Chain Gearing 188
185. Chain Guard 189
186–191. Kotin Patent Methods of Mounting Ball or Spherical Teeth 189, 190
192. Kotin Patent Ball Chain Gear 191
193. Spring Chain or Sprocket Wheel 193
194. Acatène Bevel or Mitre Wheel Driving Gear . . 196
195. Lock Patent Ball or Spherical Toothed Gearing . . 197
196–201. Barnes and Garrison Ball or Spherical Toothed Gearing. 198, 199, 200
202, 203. Drzewiecki Speed Gear for Rear Driving Safety . 207
204. Differential Double-Driving Tricycle Axle . . . 208
205. Central Driving Tricycle Axle 209
206. Enlarged Sectional View of Driving Gear shown in Fig. 205 209
207. "Crypto" Epicyclic Gearing (Vertical Section) . . 210
208. "Crypto" Epicyclic Gearing (Side View) . . . 211
209. Central Driving Gear 212
210. Modified Form of Central Driving Gear . . . 213
211. Boudard-Crawley Speed Gear 214

FIG.		PAGE
212.	Ordinary Pedal Pin	217
213.	Pedal Pin for Narrow Tread	217
214.	Birmingham Small Arms Co. Pattern Pedal Pin	217
215.	Split Cone Nut Pedal Pin	217
216.	Plain Cone Nut Pedal Pin	218
217.	Right- and Left-Hand Pedal Pin	218
218.	Cotter Pedal Pin	218
219.	Method of Attaching Pedal Pin to Crank	218
220.	Patent Rubber Ball Pedal	219
221.	Rubber Dust-proof Ball Pedal	219
222, 223.	Rat-trap Dust-proof Ball Pedal	220
224.	Bull-dog Rat-trap Pedal	220
225.	Light Roadster Rat-trap Pedal	221
226.	Patent Combination Pedal and Toe-clip	222
227.	Unbreakable Toe-clip	222
228.	Pulling Toe-clip	223
229.	Perry Toe-clip	224
230.	Humber Pattern Toe-clip	224
231.	Henson Anatomical Pneumatic Saddle or Seat	226
232.	Burgess Duplex Pneumatic Seat	227
233.	"Reform" Saddle	228
234.	Richardson Anatomical Saddle	229
235.	"Automatic" Self-adjusting Saddle	230
236.	Wide Seat Saddle	230
237.	Saddle Clip	231
238.	Saddle Leather-tightening Arrangement	231
239.	Seat Lug	232
240.	Saddle Pillar or Pin	232
241.	Humber Pattern Brake	233
242–244.	Sparkbrook Detachable Brake Lug	234, 235
245.	Kay Indiarubber Brush Brake	236
246.	Perry Simplex Brake	236
247.	Pneumatic Cycle Brake (Air-ball or Bulb)	237
248.	Pneumatic Cycle Brake (Pad or Shoe)	238
248*a*.	Pneumatic Cycle Brake (Section through Pad or Shoe)	239
249.	Foot-brake	239
250.	Perry Detachable Lamp Bracket	241
251.	Perry Feather-weight Lamp Bracket	241
252.	Perry Plate Lamp Bracket	242
253.	Serrated or Rat-trap Foot-rest	243
254.	Combined Rubber and Serrated or Rat-trap Foot-rest	244

FIG. PAGE
255. Cycle Step 244
256. Pump Clip 244
257. Midget Oil Can 245
258. Patent Adjustable Spanner 245
259. Gas Blow-pipe with Central Tap 247
260. Gas or Petroleum Forge and Blow-pipe combined . . 248
261. Gas Furnace 248
262. Tube Strengthener or Ferrule 249
263. Emery Band Machine 249
264. Patent Improved Adjustable Angular Sliding Vice . 250
265. Patent Universal Cycle Jig 251
266. Rim or Felloe Drilling Machine (Plan) . . . 253
267. Rim or Felloe Drilling Machine (Front Elevation) . 253
268. Automatic Hub-drilling Machine (Plan) . . . 254
269. Automatic Hub-drilling Machine (Front Elevation) . 255
270. Small Hub-drilling Machine 256
271. Self-acting Hub-turning Lathe (Plan) . . . 257
272. Self-acting Hub-turning Lathe (part Transverse Section) . 258
273. Wheel Erector 260
274. Factory Inflator 260
275. Special Milling Machine for Cutting Sprocket Wheels (part Side Elevation) 261
276. Special Milling Machine for Cutting Sprocket Wheels (part Front Elevation) 262
277. Lathe Attachment for Emery Grinding . . . 265
278. Double-cased Enamelling Stove or Oven . . . 267
279. Polishing or Buffing Lathe or Head . . . 270
280. Erecting Stand 279
281. Simple Form of Tube Clamp 279
282. Automatic Adjustable Tube Clamp . . . 280
283–286. Method of Forming Open or Bell-mouthed Lap-joints 285
287–289. Method of Forming Closed Lap or Scarf Joints . 286
290. Drilling Jig 287
291. Patent Flexible Steel Mandrel for Tube Bending . . 290
292. Block with Rollers for Bending Tubes . . . 291
293. Single Tube Bending Block 292
294. Spoke Drill 295
295. Spoke Cutter 297
296. Crank Drawer 299
297. Small Hand Spoke-screwing Machine . . . 300
298. Combined Spoke Grip and Nipple Key . . . 301

FIG.		PAGE
299.	Hollow Spindle Capstan Lathe	302
300.	Self-acting Screw-cutting and Surfacing Treadle Lathe .	303
301.	Bench Drilling Machine	304
302.	Patent Upright Drilling Machine	305
303.	Diagram showing Method of Laying out Epicycloidal Teeth	306
304.	Gas Cement Heater	308
	Folding Plate (Thomson's Tyre) . . *to face page*	320

MODERN CYCLES:

THEIR CONSTRUCTION AND REPAIR.

CHAPTER I.

INTRODUCTION.

SO accustomed have people become to cycles that they are accorded but little admiration. Nevertheless a well-constructed modern cycle is most undoubtedly a very clever piece of mechanism, and one that has only become gradually and slowly evolved, by the exercise of great ingenuity, from a very crude and unpromising commencement.

The prejudice, or rather the dread, which for some time prevented many people from availing themselves of this mode of locomotion, has now, with the supersession of the old front-driving high bicycle or dicycle, known as the ordinary, and the perfection of the modern machine, known as the safety, almost completely disappeared, and the cycle now not only affords a ready means to both sexes of obtaining a pleasant and healthful recreation, and admits of a rapid transit from one place to another for business purposes, but also allows of a like convenient moving from place to place of passengers or goods being effected.

The great advantage derived from the use of a well-made cycle is, that the weight of the rider being borne entirely upon the wheels, the whole of his strength can therefore be profitably exerted upon the propulsion of the machine, and, as is well known, the weight of the body in walking necessitates a far greater muscular effort than that requisite

for the above purpose, hence the gain experienced in riding a cycle.

The time for expressing any doubts as to the advantages to be derived from the use of cycles has now gone by, and the healthfulness of the pursuit when not abused is almost universally acknowledged.

In addition to the possession, however, of a good machine, it is absolutely necessary, in order to obtain satisfactory results both as regards pleasure and utility, that the surface upon which it is to be propelled be in a hard and smooth condition. It is clear, therefore, that unless the art of road-making had progressed, or rather, perhaps, to speak more accurately, the application of the said art had become more universal, the development of the cycle, even if it had not been entirely checked, would have been to a large extent bereft of its utility. In America, where the cycle, or as it is there styled, the wheel, has become, if possible, even more popular than here, special roads or tracks have been laid down for cyclists, which they are free to use upon payment of a small toll.

Before proceeding to give a short historical account of the growth of cycles, a few preliminary remarks upon the balance of bicycles will not be out of place. It is of course obvious to any one that a bicycle, being supported only at two points, cannot be stable, but must have a constant tendency to fall to the one side or the other. This tendency can be counteracted by the bicycle rider when in motion in two ways—viz., first, by inclining the body in the opposite direction to that in which the machine is falling, and, secondly, by turning the steering wheel towards that side to which the machine is falling, or, as it is termed, under-running. The latter action causes, when the machine is in motion, the recovery of the balance. In practice it is probable that the expert bicycle rider maintains his balance partly by the inclination of his body to one side or the other, and partly by under-running. The more expert the rider the less necessity will there be for correction by under-running, and consequently the straighter and the less wavy will be the path of the bicycle. In the high-wheeled ordinary, which has now almost disappeared, the rider, being seated but little to the rear of the driving wheel, was

able by means of his feet alone to effect the steering of the machine by using the cranks as levers by which to turn the driving wheel to either side as required. This fact, moreover, necessitated, upon the exertion of any considerable power upon the cranks when driving, the manipulation of the handle-bar in such a manner as to counteract the tendency to turn the wheel caused by the thrust upon the said cranks, and to prevent the machine from constantly turning to one side and then to the other. This necessity for combined action was one of the reasons that rendered it more difficult to learn to ride a bicycle of that type, and caused it, besides, to be theoretically impossible to ride one in a straight line except when running at a high velocity, and not even then whilst any considerable application of power was being made to drive it.

Brief History of the Cycle.

As the title indicates, this little treatise is intended to be mainly devoted to the construction and repair of modern cycles; therefore, although of undoubted interest, the historical part of the subject must, perforce, be here represented by a very brief outline only. Those readers desirous of going fully into the development of the cycle, from the first crude sample up to the present comparatively perfect machine, will derive much interesting information by turning to the many notices, articles, &c., contained in the pages of the *Engineer*, *Engineering*, *English Mechanic*, *Scientific American*, and of the various other technical journals, the journals devoted especially to cycling matters, the papers read from time to time before some of the literary and scientific institutions and societies, and the annals of the Patent Office.

The cycle or velocipede may be defined as a kind of carriage impelled by the exertions of the rider.

The *Journal de Paris* described a velocipede in 1799 which was the invention of Blanchard and Magurier, and which some few years after, in an improved form, was known as the accelerator.

Fig. 1 shows the old dandy or hobby horse, which was propelled by the thrust of the feet on the ground.

The next step in advance was the adoption of crank mechanism to the wheels, arranged to be driven by hand through other cranks or wheels. The bicycle invented by the Baron de Drais, and improved by Louis Gompertz, was driven by a hand lever operating through a toothed quadrant and pinion, assisted by the thrust of the feet on the ground, as in the hobby horse.

One M'Millan is said by some, and Gavin Dalzell by others, about the year 1840, to have first fitted cranks to a machine of the hobby-horse pattern, in this country. The cranks were driven through pendulum levers connected to the former by suitable coupling rods, and the said cranks were secured upon the axle of the rear wheel.

M'Kenzie's patent machine had a cranked axle, arms and

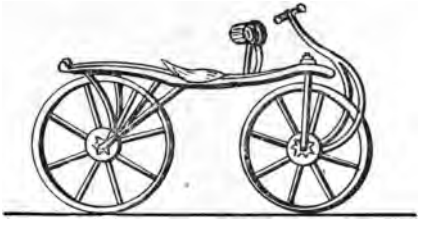

FIG. 1.—Dandy or Hobby-horse.

foot rest, so arranged that power applied by the feet of the rider could be utilised for giving motion to the vehicle. This was a three-wheeled velocipede.

In Pickering's bicycle, the handle-bar or tiller was sufficiently elevated to enable an upright position to be maintained whilst riding. The pedals were triangular shaped in transverse section, and were rotatably mounted upon the crank pins, thus the pressure of the foot thereon would always cause one or other of the three flat sides to come in position for the foot. The shape of the pedals, moreover, was such that they would be operated by the fore part of the feet, thereby allowing the ankles to be brought into play, and thus relieving the knees of the rider.

Wheels with wire spokes seem to have been invented by

F. G. M. Stoney, who, in 1863, made a quadricycle with two rear-driving wheels of 5 feet in diameter, and two leading wheels of 4 feet in diameter, the spokes of which were made of No. 17 steel wire, or 0.06 inch in diameter. A photograph of this machine was exhibited by the inventor at a meeting of the Institution of Mechanical Engineers, held in 1886.

Fig. 2 shows the "bone-shaker" of 1869. The addition of cranks to the fore wheel rendered it necessary to increase the amount of load thrown upon it, as otherwise sufficient adhesion with the ground to obviate slips could not be obtained. The weight of the rider being thus principally

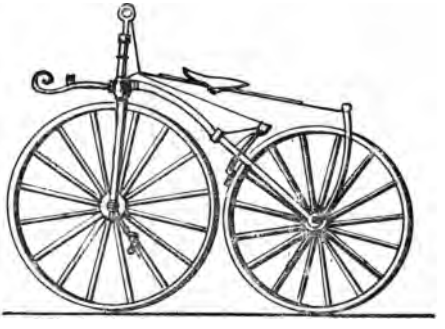

FIG. 2.—"Bone-shaker."

carried by the fore wheel, it was found that the rear wheel could, on account of its lighter load, be reduced in diameter. This machine was of French origin.

It may be here noted that in 1868, about a year before the date of the improved bone-shaker machine just mentioned, a well-known engineer, the late E. A. Cowper, seems to have invented before its time a machine which comprised most of the essential elements of a first-class cycle of the present day. Amongst the features covered were, a suspension wheel with wire spokes, hollow rims or felloes, rubber tyres, and anti-friction ball bearings. Unfortunately for himself, he neglected to patent his invention, being persuaded by his friends that the demand

for cycles would never be likely to be sufficient to recoup him for the outlay.

We find also a provisional application in this same year by L. F. A. P. Riviere, No. 1093 of 1868, which contains what might be construed into a description of a very practical machine of this crude type. The axle of the front wheel was to be fixed to, and rotate with, the wheel itself, and to pass through bearings formed in the vertical steering fork of the cycle, and each end of the axle was to be provided with a crank having a balanced foot-plate, so that the rider might be able to impart motion to the machine through the cranked axle which actuated the front wheel. The seat or saddle was to be supported by a spring, and a cross handle was to be provided for actuating the steering fork of the first wheel. This cross handle was connected through a strap to one end of a lever of the first order having its fulcrum in the main beam of the machine, and the lever was so arranged that by partially rotating the cross handle upon its axis the front end of the said lever would be drawn up, and its lower end simultaneously actuate a spring brake which would be thus pressed against the periphery of the back wheel of the machine, thus retarding its motion as desired. When not required to be used the lever was kept out of action by a spring provided for the purpose. The two wheels were to be truly in line with each other, and the front wheel was to be preferably of somewhat larger diameter than the back one.

It would be utterly impossible within the space at command to trace with any degree of detail the rapid progress made in the manufacture of cycles from the bone-shaker illustrated in Fig. 2 up to the comparatively perfect modern safety of 1896. A few links in the chain, however, which space only will admit of, may not prove uninteresting.

Amongst the claimants to the inventorship of the safety bicycle in this country is H. J. Lawson, who is said to have first made a machine of that type at the Fairfield Works, Coventry.

Fig. 3 illustrates the ordinary or high bicycle or dicycle for road riding as used in 1885. The front or

driving wheel of a bicycle of this class was of as large a diameter as could be reached by the rider, whilst the rear or trailing wheel was of as small a diameter as possible consistent with carrying sufficient rubber tyre to withstand the increased wear due to its shorter circumference. An average bicycle of this class was of about 40 lbs. dead weight, and the position of the saddle could be so adjusted that about 90 per cent. of the weight of the rider was supported by the large front wheel, and it followed therefore that only about 10 per cent. of the said weight would come upon the small trailing or rear wheel.

FIG. 3.—Ordinary or High Bicycle.

The want of forward stability in the high ordinary, and the consequent liability to more or less serious accidents when passing over any slight obstruction upon the road, or even upon the sudden application of the brake (when fitted) to the front or large wheel, led to the adoption about 1885 of the class of machine known as safeties, of which those styled the "Facile," the "Xtraordinary," the "Challenge," the "Kangaroo," and the "Club" (Fig. 4), form typical examples.

In all these bicycles the weight of the rider was placed much further to the rear, special mechanism, such as elliptical or other lever action as in the first two, or chain wheels and chain gearing as in the three latter, being employed to bring the pedals into a position more directly under the saddle. It would seem at first sight that the addition of this driving mechanism must result in loss of

efficiency owing to the extra friction developed, and also by reason of the additional amount of load imposed upon the small wheel. In practice, however, the contrary effect was found to be produced. This advantage in a dwarf bicycle may be attributed to a combination of several causes, viz., firstly, a considerable reduction in the wind pressure; secondly, that the rider is enabled to sit in a more advantageous position relatively to the cranks; thirdly, that the driving wheel can be geared up to any extent so as suit the rider, and allow of his obtaining a high velocity with a comparatively slow action of the pedals. To this

FIG. 4.—The "Club" Safety Bicycle.

latter feature, most probably, is due the greater part of the gain experienced. The reason for this is not far to seek, men or any other animals become soon exhausted if obliged to move their limbs rapidly, and are able to apply their strength much more advantageously if allowed to make a greater effort at a slow speed. In addition to this the greater stability enjoyed by the rider admits of his performing a larger amount of work.

All these dwarf safety bicycles, however, being front drivers, were as difficult to learn to ride, for the reasons already given on page 3, as the old high bicycle or

ordinary, with the important exception, however, that the rider was not perched at so great a height from the ground and occupied a more stable fore and aft position.

A rear-driving safety bicycle, which also dated from about 1885, is that which was known as the "Rover"; and amongst other rear-driving safety bicycles which were contemporaneous with the latter, mention may be made of an American machine called the "Star," one made by the Birmingham Small Arms Factory, the "Humber," and the "Kaiser." Referring to that known as the "Rover," the fore wheel, which was the steering wheel, was slightly larger in diameter than the rear-driving wheel. This was found to be an advantage, as it greatly reduced resistance, and, likewise owing to the greater gyroscopic stability imparted by the larger wheel, considerably improved its steering capacity. The larger front wheel, however, has the disadvantage of necessitating a heavier frame. In all of the other rear drivers above mentioned, except the "Rover" and the "Kaiser," which latter had equal wheels, the fore wheel is the smaller, an evidently objectionable arrangement, inasmuch as they are bound to carry a far larger proportion of the load than that imposed upon the trailing wheel of an ordinary or high bicycle, viz., upwards of one-third of the said load. The position of the small wheel, moreover, in front renders it especially liable to sink into any loose or soft surface, and imparts a far more severe jar to the rider when passing over any obstruction, and also causes a constant increase of vibration. The brake could, however, be put "hard on" suddenly without any such disastrous results as inevitably followed with a high ordinary, where the rider sat only a few inches behind the centre of gravity.

The "Kaiser" safety bicycle, which dates about the same time as the machine just mentioned, was designed by J. Alfred Griffiths. The load is placed at a point about equidistant between two wheels of equal diameter, and medium size. The seat is placed upon the top of a pillar hinged at its lower extremity close to the treadle or crank axle. This swinging saddle pillar is coupled to the steering head through a strong spiral spring, so that the rider would be balanced between the forward pull of the spring, and the horizontal

component of his own weight on the saddle tending to rake backwards.*

Space does not admit of tracing step by step the gradual evolution of the present improved patterns of safety bicycles or dicycles from the cruder forms we have just particularised. The advances since made, indeed, have been more in minor details of construction than in any radical departure from the principle upon which the first successful machines of this type were built.

The same reason renders it necessary to here entirely pass over any account of the earlier patterns of tricycles, multicycles, and the many miscellaneous types of cycles, the advances in the construction of which, however, have kept pace with, and are intimately bound up in that of bicycles or dicycles, and which progress will be slightly alluded to when dealing with the modern machines.

We will now, therefore, proceed in the succeeding chapters first to describe shortly and illustrate a selection of typical modern machines by some of the best known makers, and subsequently to deal more particularly with their component parts, the details of their construction, and with the not unimportant subject of repairs and renewals thereto.

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* For further description and particulars of advantages claimed for this swinging seat pillar, see *Proceedings Inst. Mech. Engrs.*, 1886.

CHAPTER II.

Modern Safety Bicycles or Dicycles.

MODERN safety bicycles, or, as they should more accurately be designated, dicycles, may be conveniently divided into five main or principal classes—viz, roadsters; racers; machines adapted for ladies' use; tandems, triplets, quadruplets, quintets, sextets, and other single track multicarriers; and, finally, convertibles—that is, machines capable of being readily altered so as to render them fit for one or other purpose, as, for instance, either for use by gentlemen or ladies.

The weight of bicycles in 1879 was from 35 to 60 lbs., whilst that of those of modern make is only from 18 to 33 lbs. With this decrease in weight, however, has come a corresponding decrease in strength, the factor of safety in a first-class machine of the present day not exceeding $1\frac{1}{2}$. It is evident that so small a margin of safety demands a careful and judicious usage to avoid accidents, and every rider, therefore, should make himself acquainted with all the weak points of the machine, and what strains they are capable of supporting.

The variations in efficiency in well-built cycles are mainly due to the constantly varying speed, the more or less perfect lubrication of the axle bearings, the diameters and conditions of the tyres, and, finally and chiefly, to the state of the road surface over which propulsion has to be effected. Consequently but little variation in resistance can be detected in high class cycles when tried upon comparatively plane surfaces, such as those afforded by the floors of show rooms. When, however, run at a good speed upon an average road, the advantages derivable from a proper dis-

tribution of wheel load, wheels of judicious diameter, &c., are not slow in manifesting themselves.

It is perfectly clear that the size of wheel will affect resistance in two ways—viz., air resistance, and rolling resistance. On practically level surfaces the rolling resistance of a wheel of small diameter will not be found to be greatly in excess of that of one of a larger diameter, whilst possessing the additional advantages of affording a considerable saving of dead weight and in air resistance. This latter quality is of no small importance, inasmuch as whilst but little opposition is offered by wheels with wire spokes to the passage of air in a lateral direction, on the other hand, when rapidly rotating, they create a vortex or whirl of air of a somewhat larger diameter than the wheel, which will naturally cause as great a resistance against advance as would a solid body of equal dimensions. When, however, the surface to be traversed is either uneven or strewn with stones or other obstructions, or is of a soft and yielding nature, or muddy and heavy, the smaller the wheel the greater will be the rolling resistance. The objection to a small wheel, raised on account of the shorter length of tyre which comes in contact with the ground, necessitating an increased expenditure of power in the internal grinding of the rubber, can be satisfactorily overcome by using a broader tyre, but the suddenness of the lift imparted to a wheel with a solid tyre when passing over stones or other small impediments upon the road, and the consequent increase of friction on the bearings, and resultant unsteadiness of driving and jolting or jarring and vibration, are irremediable.

With a pneumatic tyre, however, this latter objection is to a great extent obviated, for the shock of charging a stone or other obstruction of say one inch would be practically completely absorbed by a 2-inch pneumatic tyre.

In order to overcome the want of lateral stability to which bicycles with the wheels in line one behind the other are liable, attempts have been made to increase the width of the wheel base. For this purpose R. J. Peat Spence, in his patent No. 23,086 of 1895, employs a double-tyred, double-rimmed or felloed wheel—that is to say, a wheel so arranged as to bear at two or more places upon the ground. He

also mounts two wheels close together upon the same axle. This latter arrangement, however, becomes rather a narrow tricycle than a bicycle. Attachments with arms carrying small wheels at their extremities, which arms can be moved outwards sideways by the rider, have been also designed.

In a very interesting paper on the "Distribution of the Wheel Load in Cycles," by J. Alfred Griffiths,* the author lays down the following five points of efficiency as applicable to cycles generally:—Reduction of dead weight; reduction of resistance; perfection of load distribution; stability when in motion; and finally, proper arrangement of load and driving mechanisms.

The efficiency of cycles will be more fully discussed later on in a chapter devoted especially to that subject.

FIG. 5.—Humber Roadster Safety.

ROADSTERS.

In judging of the efficiency of a cycle, due account must be taken of the purpose for which it is intended. In the present instance dealing with roadsters—that is, bicycles or dicycles intended for general road riding and touring, these machines must be fit for propulsion upon the ordinary

* *Proceedings Inst. Mech. Engrs.*, 1886.

country roads, the larger portions of the surfaces of which are not smooth, but have on the most favourable parts even greater or lesser extents of undulations, and which, besides, present surfaces of ever-varying nature and gradient.

Figs. 5 to 9 illustrate various rear-driving roadster bicycles or dicycles of the most improved recent patterns, constructed by some of the best-known makers.

Fig. 5 shows a Humber roadster safety, which is a type of machine especially suitable for touring and for general purposes. The machine is fitted with either 28-inch equal wheels, or with a 30-inch steering wheel and a 28-inch

FIG. 6.—Starley Brothers' Roadster Safety.

driving wheel. The spokes are of the tangent pattern, and the rims hollow. It has ball bearings throughout. The cranks are 6½-inch, fitted with 4-inch rubber pedals, and it is geared to 60 inches. It has a detachable spoon brake, with renewable rubber shoe, and light detachable mud-guards. The tread of this machine has been reduced to 5½ inches, and there is sufficient clearance for the use of 2-inch tyres if desired. It is fitted with a swing chain adjustment, and with a skeleton fork crown and interchangeable combination crank and chain wheel. Both the spoon brake and mud-guards are, as above mentioned, entirely detachable, and

when removed, moreover, leave no trace of having been fitted. A standard machine of this class is suitable for riders up to 14 stone. The weight of the machine, with $\frac{3}{4}$-inch rubber tyres, is 33 lbs.

Fig. 6 shows a light roadster made by Starley Brothers. The tread of this machine is very narrow, being only $4\frac{1}{2}$ inches. It is fitted with detachable flat cranks, pedals of a patented dust-proof type, and with an improved chain wheel with geometrical detachable disc for changing gear. The driving chain is of the hardened block type, and a dust-proof crank bracket is provided. The machine is nor-

FIG. 7.—Premier Cycle Co. Ltd. Roadster Safety.

mally geared to 64 inches. The saddle pillar is adjustable, there is an improved type of ball head, also completely detachable gear case and lubricator, and brake and guard with stop link motion. The wheels have double hollow rims of the Westwood pattern, the rear one being fitted with double-butted tangent spokes, and they are 28 inches by $1\frac{1}{2}$ inch. The frame is of best cold-drawn weldless steel tubes, all the main tubes being $1\frac{1}{8}$-inch cross sectional diameter, and the top tube 1-inch.

The Rudge-Whitworth full roadster bicycle has 28-inch front and rear wheels, with jointless patent hollow rims. Patent interchangeable 60-inch gear and special block

pattern chain. The cranks are $6\frac{1}{4}$ inches in length and detachable. The tread is reduced to $4\frac{7}{8}$ inches from face to face of crank, and allows sufficient clearance for a gear case. The handle-bar is straight and admits of an erect position being maintained, and the machine is fitted with a detachable rubber-faced brake, and special detachable corrugated pattern mud-guards. The weight of this machine is 38 lbs., and it is suitable for heavy riders, or for use upon unusually rough uneven roads.*

Fig. 7 is a roadster machine illustrating one of the standard patterns made by the Premier Cycle Company Limited. A special feature of this machine is the frame,

FIG. 8.—Sparkbrook Manufacturing Co. Ltd. Roadster Safety.

which is of patent helical tube made from crucible cast steel, converted from Swedish (Dannemora) iron.† It is fitted with 28-inch wheels with tangent spokes, and has a new detachable form of brake clip, and a patented suspension rubber brake. The weight of the machine complete with $1\frac{3}{4}$-inch tyres, saddle, pedals, brake, and guards, is about 32 lbs.

Fig. 8 is a roadster built by the Sparkbrook Manufactur-

* The special features of the above cycle will be found described in the chapter on Component Parts.

† For further description and illustration of this patent form of tube, see chapter on Component Parts.

ing Company Limited. The frame of this machine is of the "weldless" brand of steel tube, and the joints and bottom bracket are of a special character, which, it is said, ensures great strength and rigidity, and in which there is no cross-grain in the metal, the latter always running in one direction. The wheels are 30-inch front and 28-inch back, are fitted with tangent spokes, have special hollow rims, and dust-proof and oil-retaining hubs.

The advantages claimed for the section of hollow rims

FIG. 9.—S. Drzewiecki "Cyclet" Roadster Safety.

used are as follows:—It is absolutely true and round, and consequently makes a perfect wheel, and in building allows all the spokes to be drawn to an equal tension. Owing to its shape, it is an easy rim from which to detach the Dunlop tyre, and at the same time it normally holds the tyre so firmly that there is practically no chance of its blowing off when fully inflated. There are five thicknesses of steel folded over at the edges, which gives great lateral stability, and renders it almost impossible for the rim to be damaged by impact with any ordinary obstacle, such as a large stone,

on the road. The rim, moreover, is made of a very high grade of steel, and being well finished, it adds greatly to the appearance of all machines fitted with it.

The cups, cones, and balls are of the best diamond steel, and the cups and cones are all carefully ground true after hardening, and the balls gauged by hand. The head adjustment is such that it can be operated independently of the handle-bar and *vice versâ*. The fork crown is of steel.* The machine is geared to 60 inches or as may be desired, and its weight, including roadster tyres, saddle, and pedals, is about 33 lbs.

Fig. 9 illustrates a rear-driving machine wherein toothed gearing is substituted for chain gearing as a motive power. This machine, which is the invention of S. Drzewiecki, is called the "Cyclet." As will be seen from the drawing, the driving mechanism is on the sun and planet system, the pedal cranks being fixed to the large internally toothed wheels.† Amongst other advantages claimed by the inventor for this type of machine are the following:—The saddle being placed directly over the driving cranks, enables the rider, whilst retaining an upright position, to bring his entire weight to bear upon the pedals. The pedals rotating well within the circumference of the driving wheel, admits of the wheels being placed much closer together, and so very considerably reducing the length of the machine, whereby not only is the frame rendered much stronger and more rigid, but the machine can be turned in a far smaller space. The weight of the rider is almost entirely carried by the rear-driving wheel, thereby rendering any slip a matter of impossibility, and greatly reducing the weight upon the fore wheel and fork, the latter of which is the weakest and most often broken part of a machine of the usual pattern.

It will be seen that this machine is fitted with a brake operated by a rod or plunger passing through the head, and a crank arm or lever upon the handle-bar, which latter

* Descriptions and illustrations of many of the special features of the above machine will be found under the proper headings in the chapter on Component Parts.

† For further description and illustration of this driving gear, see chapter on Component Parts.

is pivoted so that the said brake can be applied by pulling the bar towards the rider. The position of the rider directly over the driving cranks and the shortness of the machine render the use of this brake possible. It would be obviously inapplicable to the standard patterns of rear chain-driven safety machines which necessitate in every case when driving at any speed, owing to the position of the rider relatively to the driving cranks, a more or less bent posture, which latter is generally maintained by pulling on the handle-bar. A fault to which this machine would appear to be especially liable is a great want of rearward stability.

Amongst other modern machines may be mentioned the Imperial Rover, the well-known recent pattern of the original Rover of 1885, made by the Rover Cycle Company Limited; and the Columbia bicycle made by the Pope Manufacturing Company, U.S. The standard pattern machine of this company has 28-inch wheels with laminated wooden rims, and tangent spokes 28 to front and 36 to rear, and $1\frac{5}{8}$ inch Hartford tyres. The frame is 23 inches, steering-head 10 inches, handle-bar 19-inch reversible, with vulcanite and cork handles. Patent crank-shaft bearings with $\frac{3}{8}$-inch balls. Detachable front and rear chain or sprocket wheels fitted with an improved Elliott self-oiling chain, $6\frac{3}{4}$-inch cranks, $3\frac{5}{8}$-inch rubber pedals, $5\frac{1}{4}$-inch tread. T-shaped tubular saddle stem. It is geared to 66 inches, and weighs with $1\frac{5}{8}$-inch road tyres and regular equipment $22\frac{1}{2}$ lbs. A special feature claimed for this bicycle is the construction of the crank-shaft, with which the cranks are mechanically one piece, with no keys or nuts to work loose or catch in the clothes, or requiring force and skill to remove and replace. The joint is formed by means of right and left handed threads in a revolving sleeve, the revolutions of the cranks tending to make the joining of the parts in the centre of the sleeve firmer and closer, and there being no danger of loosening through back pedalling inasmuch as the said sleeve still continues to revolve in a forward direction. This device allows of a narrow tread and at the same time permits of the provision of an extreme width between the bearings. The cranks can be expeditiously removed without any necessity for the application of force or in any way affecting or disturbing the bearings. The

use of wooden rims in this machine affords the advantage of lightening the wheels, and, according to American authorities, does not render them much, if any, less durable.

In a type of machine made by the Bamboo Cycle Company Limited, the frame is principally constructed of bamboo. The design of the framework of this machine is practically similar to that of other modern cycles, the essential point of novelty being in the material employed in its construction. It has a 7-inch head, and horizontal top rail. The rear or driving wheel is 28 inches and the front or steering wheel

FIG. 10.—Crypto Works Co. Ltd. "Bantam" Roadster Safety.

30 inches; the rims are either hollow metal, or wood. Both the brake and mud-guard are readily detachable. The weight of the machine complete is 28 lbs.

The bamboo tubes are undoubtedly very strong, in fact they are weight for weight much stronger than steel ones. The great difficulty would seem to be, as indeed with steel tubes, in the formation of sound and lasting joints, and if the method employed of fastening these joints * is as strong as the makers claim it to be, then the bamboo, or

* For description and illustration of various methods of forming the joints, see chapter on Component Parts.

rather the combination of bamboo, aluminium, and steel, should form both a strong and durable cycle.

Fig. 10 illustrates the standard pattern of front-driving safety bicycle built by the Crypto Works Company Limited, which is known as the "Bantam." The driving gear is of the multiplying type.* The machine is provided with a ball socket head and a plunger brake. The rear wheel is 20 inches, and the fore either 22 inches, 23 inches, or 24 inches, geared to 60, 63, or 66 inches. The weight with saddle and pedals is about 28 lbs. A lighter machine is also made which has wheels with wooden rims, semi-racing saddle, and is without brake, the frame, &c., being also carefully lightened wherever possible. The weight of this light roadster is only 23 lbs. An advantage of some importance possessed by this little machine is that any person of fairly average activity can readily acquire the art of balancing without assistance and without any fear of falling. It is likewise very compact in build, measuring only 4 ft. 4 in. over all, instead of 6 ft. 2 in. as in the case of the rear-driving chain safeties. The position of the rider is very advantageous relatively to the pedals, vibration is reduced to a minimum, and there is a large range of adjustment which renders the machine capable of being ridden by riders of great disparity in height. The machine is also an excellent hill-climber, and the writer can testify from personal experience as to its many good qualities.

The gear is very lasting, much more so indeed than the ordinary driving chain. The advantages and disadvantages of the driving gear will, however, be more fully gone into later on, in the chapter devoted to component parts.

The balance to be acquired is analogous to that of a high front-driven bicycle, which is, as has been already mentioned, somewhat more difficult than that required on the rear-driven safety; the extreme lowness of the machine, however, in this case facilitates its acquisition.

RACERS.

A good roadster, which possesses an economical applica-

* For description and illustration of this driving gear, see chapter on Component Parts.

tion of driving power, and with a distribution of wheel load suitable for use on the average roads of varying surface and gradient, will, if permanently adjusted as though the road were not level, but a continually ascending gradient, and that the maximum amount of the rider's energy can be thus utilised by being converted into velocity, and, furthermore, if stripped of brakes, seat springs, foot rests, appliances for climbing hills and for varying the driving power, baggage holders, and, in fact, of all such adjuncts as are not required upon the racing path, forms the best possible racer. The five points of efficiency laid down by Griffiths, mentioned in the previous section, apply with equal aptitude to this, as indeed to every other type of cycle.

As therefore the patterns of bicycles or dicycles especially designed for racing purposes both on the road and on the path only differ from standard roadsters in the greater lightness of the frames, wheels, saddles, &c., and in their adjustment, it is unnecessary to illustrate them.

The weight and usual gearing of racing machines, constructed by some of the firms whose roadsters have been taken in the previous section as illustrative of modern practice, are as follows:—Humber & Co. Limited special road racer safety, with 1⅜-inch and 1½-inch tyres, 25 lbs.; gear 63 inches or 70 inches. Path racer safety, from 19 lbs. to 22 lbs., according to rims and tyres; gear 72 inches. Rudge-Whitworth special road racer safety, 1⅝-inch tyres, geared to 64 inches, weight 26 lbs. Special racing safety, 1½-inch back and 1⅜-inch front tyres, geared to 68 inches, weight from 21 to 24 lbs. Premier Cycle Company Limited road racer about 26 lbs.; geared to 64 inches. Path racer, weight complete, about 22 lbs. The Sparkbrook Manufacturing Company Limited road racer, weight 25½ lbs. Path racer, 22 lbs. The fashion has lately tended more and more to the use of high gearing, and, consequently, both in the case of roadsters and racers, the gearing is not uncommonly considerably higher than those mentioned.

Machines Adapted for Ladies' Use.

Some seven or eight years ago, at a debate on athletic exercises for ladies, one of the speakers, inspired perhaps by a prophetic spirit, happened to speak of the benefits that

would be derived by ladies from the exercise of riding bicycles. The suggestion that ladies should appear publicly mounted upon bicycles, at that time, appeared so preposterous to the audience that it was greeted with a burst of laughter.

At the present day the number of female cyclists using bicycles bids fair in a short time to rival, if not to exceed, that of males. Nor has it been found necessary for them to adopt any of the unbecoming so-called cycling dresses in order to enjoy the pastime.

As examples of ladies' safeties, the following, built by

FIG. 11.—Humber Lady's Safety.

some of the firms types of whose roadsters have been already given, will afford a sufficient idea of the standard patterns of modern machines.

Fig. 11 illustrates a Humber lady's safety. It has either 28-inch equal wheels, or 28-inch fore and 26-inch rear or driving wheel if desired, and either 6¼-inch or 6-inch cranks. Tread 5¼ inches. Geared to 56 inches or 60 inches. Weight, fitted with 1⅝-inch tyres, 31 lbs.

A lighter machine of the same pattern, weighing only from 26 to 28 lbs., according to size of tyre, is also made by the same Company. Also several different pattern machines, in

one of which the upper frame tube, instead of being carried from the base of the steering, is brought from the top of the latter, and is led by a suitable curve to the same point on the seat pillar tube as in Fig. 11. This latter machine is likewise made in both weights as mentioned above. Another pattern has a curved or loop frame, which is adapted to give more space between the saddle and the handles, and allowing ample room for the dress. The last machine weighs about 35 lbs.

A machine is also made by this Company with a self-locking frame, specially designed by C. W. Brown, in order to provide a dropped or open front that would be actually

FIG. 12.—Starley Brothers' Lady's Safety.

as rigid as the ordinary diamond pattern, which latter is rendered unfit for the use of ladies wearing ordinary cycling costumes by the upper tube. This pattern of frame * not only ensures great strength and rigidity, but also ample room for the rider's dress.

One pattern of Starley Brothers' ladies' safeties is shown in Fig. 12. This machine has a curved or loop frame allowing plenty of room. The wheels are 28-inch by $1\frac{3}{4}$-inch back, 28-inch by $1\frac{5}{8}$-inch front. The handle-bar is of a

* For description and illustration of this pattern frame see chapter on Component Parts.

raised tapered design. The width of the tread is 4½ inches from outside to outside of crank. The machine is geared to 60 inches. The weight of the cycle, including tool-bag, spanners, and all necessary accoutrements, is under 29 lbs.

This firm claims to be the first to have introduced the loop frame ladies' safety bicycle in 1887, and since its first production its characteristic features have remained practically the same, such alterations in detail only having been found necessary from time to time as were required to bring it up to date.

Figs. 13 and 14 represent respectively a lady's safety made

FIG. 13.—Premier Cycle Co. Ltd. Lady's Safety.

by the Premier Cycle Company Limited, and one made by the Sparkbrook Manufacturing Company Limited. The design of the dropped or open-fronted frames in both these examples is very similar, the first, however, being constructed of the Premier helical tube. The weights of these machines are as follows:—Fig. 13, complete with saddle and pedals, 31 lbs.; Fig. 14, 30 to 31 lbs.

A machine has been lately brought out in the United States which was primarily designed solely for ladies' use, but which is also suitable for, and has been taken up to a considerable extent by, men. This bicycle or dicycle, which

possesses some novel features, consists essentially in a frame forming a triangle, of which the front and rear forks make up two sides. At the apex of this triangle is a seat which, owing to the shape and position of the handle-bar, &c., somewhat resembles that of a chair. The machine is rear driven, and the front or steering wheel is of much smaller diameter than the said rear or driving wheel. An important point is the method of arranging the steering, the pillar passing up betwen the rider's legs, and the handle-bars starting from a point behind and slightly below the level

FIG. 14.—Sparkbrook Manufacturing Co. Ltd. Lady's Safety.

of the seat, and curving round at each side of the rider like the arms of a chair. The handles are so designed and placed that the rider can stretch his arms to their full length, and his shoulders, hands, and the crank pedals are in line with one another, thus enabling the machine to be propelled, whilst maintaining an erect position, with the head up and the chest thrown well out. The weight of a strongly built roadster machine of this type is only 19 lbs. An obvious objection to this machine is the small front swivel pilot wheel, which increases the resistance, and shocks when passing over any small obstructions.

Bicycles or Dicycles for Two or More Riders.

These may be further classified under two heads—viz., first, those wherein the riders are placed in line one behind the other, such as one-track tandems, triplets, quadruplets, quintets, sextets, &c.; and those wherein the riders are situated side by side, as in one-track sociables.

Tandem Bicycles.—The first tandems were designed by Rucker, whose earliest machine consisted simply of two high wheels provided with forks and coupled together by a suitably jointed backbone. This machine afforded the advantages of having no small wheels to cause an increased resistance to propulsion, great fore and aft stability, good distribution of wheel load, and of both wheels being to an equal extent drivers and steerers. On the other hand, however, a considerable amount of practice would be required to ensure the combined action on the part of the riders, requisite for steady steering, and balancing when going round curves.

A later Rucker tandem had two wheels, the rear one being a small-sized trailing wheel, and the other or fore wheel being a medium-sized driving wheel. It was, in fact, simply a dwarf bicycle with a horizontal portion of backbone, the seat for the front rider being placed directly over the centre of the driving wheel, and that for the rear rider, who performed the steering, and should be the heaviest of the two, being about half-way between the two wheels. The driving was effected by means of divided pedal axles located in front of and behind the fore wheel axle, each being connected to the latter by a chain and chain wheels. The weight of this machine was about 55 lbs., and at the time of its introduction it was considered to be a fast machine. The forward stability of the machine, however, was not greater than that of an ordinary bicycle.

The Shakespeare, and Renouf's tandems, and a tandem machine of American design, are simply modifications of the old hobby-horse, wherein a seat for a rider is placed over each wheel, and the latter provided with driving cranks and pedals. In the American machine the rear seat could be used either as a side saddle for a lady's use, or as an ordinary saddle for men.

Figs. 15, 16, and 17 illustrate three patterns of tandems of the most recent designs, built by Humber & Co. Limited. That shown in Fig. 15 is adapted for use by a lady and gentleman, or by two ladies, in the latter case the detachable rear top stay must be removed. The machine can also be so arranged as to admit, when used by a gentleman and lady, of the latter occupying either the front or rear seat. The front, and, if desired, the rear driving chain may be provided with a cover. The frame is of Brown's patented design, and is very rigid, being stiffened by the special arrangement of the lower tubes. It is fitted with 28-inch equal wheels, tangent spokes, can be steered from either the front or back, and has ball bearings to both steering

FIG. 15.—Humber & Co. Ltd. Tandem.

heads and other parts. Front cranks 6¼-inch, rear cranks 6½-inch, gear 63 inches. The locking arrangement for the steering is a patented device (No. 3,618[95]), which consists essentially of a small pin fitting through a hole in the handle-bar collar or clip, and a similar hole in the top joint of the frame. This pin is hollow, and has fitted in it another pin having a flange upon one portion, and which latter inner pin works in an eccentric manner in the outermost one. The said outermost hollow pin is provided with a slot or opening through which the flange or projection upon the inner pin can be made to project. The hole in the handle-bar collar is recessed to receive this flange, and when the inner pin is so turned or rotated as to

cause the engagement of its flange or projection with the said recess the steering becomes firmly locked. The inner key can be turned so as to lock or unlock the steering, by means of a key applied at the top. An advantage of this steering lock is the absolute impossibility of its becoming accidentally locked whilst riding.

Fig. 16 is a tandem machine of the open-fronted pattern. The advantages claimed for this type of machine are that it is especially suited for a female-rider in front, there being ample room provided to allow of a lady's dress hanging freely, a perfect novice being able to mount without difficulty and ride with ease and comfort, and finally in the event of an accident the lady being enabled to clear herself rapidly,

FIG. 16.—Humber & Co. Ltd. Open-Fronted Tandem.

and being therefore less liable to receive injury. The front or lady rider, moreover, occupying a position nearly central between the two wheels, all oscillation and vibration are practically got rid of. The steering, which is effected from the rear handle-bar, is also said to be very perfect.

On the other hand, however, the somewhat smaller size of the front or steering wheel would undoubtedly slightly increase the difficulty of propulsion upon uneven, or soft surfaces.

The size of the rear or driving wheel is 28 inches and of the front or steering wheel 22 inches, the spokes are of the tangent pattern. The cranks for the rear rider are $6\frac{1}{2}$ inches, and the cranks for the front rider 6 inches. The

machine is geared to either 60 inches, 63 inches, or 66½ inches. A powerful tubular brake acting upon the tyre of rear wheel is provided, also light detachable mud-guards, and leather chain guard. The weight of the machine as illustrated is 55 lbs.

The tandem machine illustrated in Fig. 17 is more especially intended for racing purposes, and is made in two forms, viz., one built more especially for road racing, and one intended for path racing, the design of the framework being practically identical for both types, but the latter machine being, of course, further lightened as far as possible. The framework of this tandem bicycle has been considerably stiffened and strengthened by the addition of the

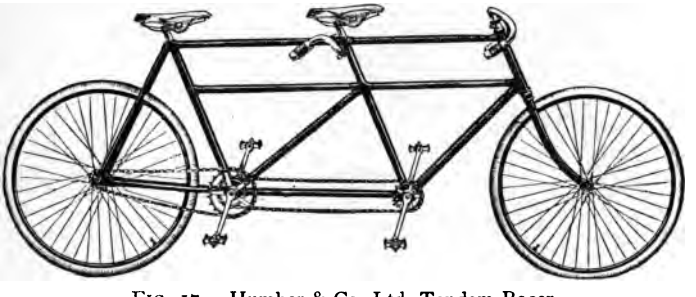

FIG. 17.—Humber & Co. Ltd. Tandem Racer.

diagonal stay which runs from the front saddle pillar to the rear bottom bracket, so as to thoroughly brace the structure. An improved adjustment is also fitted to the front bottom bracket. The machine is single steering. The rear handle-bar, which does not operate the steering, is of an improved design which forms the subject-matter of a patent, viz., No. 14,768[95], and is so arranged that the bar itself is capable of being tilted to any desired angle with respect to the pillar or stem. This handle-bar, moreover, can be so inserted in the framework that the pillar will be either above or below the bar, four distinct different positions being thus attainable, whilst in each of them the handles can be tilted to any angle. The advantage

of this adjustable handle-bar is, of course, that it can be readily adjusted to suit almost any rider.*

The road racer has 28-inch equal wheels, with tangent spokes and hollow rims, 6¼-inch or 6½-inch cranks, 3¾-inch rat-trap pedals. It is geared to 70 inches, has ball bearings throughout, and is provided with spring racing saddles, step, and lamp bracket. The path racer has similar wheels 6¼-inch cranks, 3½-inch rat-trap pedals, and is geared to 88 inches. It is fitted with no step or lamp bracket.

TRIPLETS, QUADRUPLETS, &c. — These machines are chiefly introduced for the purpose of record breaking, and the fastest mile ever ridden in England on a race path up to the present date was performed upon a Humber triplet bicycle of the type illustrated in Fig. 18. The design of

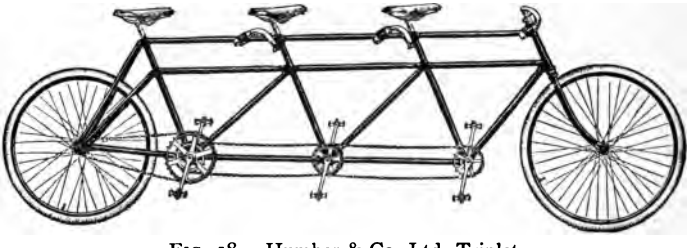

FIG. 18.—Humber & Co. Ltd. Triplet.

the frame is, it will be seen, on the same lines as that of the tandem shown in Fig. 17, its stiffness and rigidity especially lending itself to these extended types of machines. The handle-bars and other details are also similar. The front-steering wheel is 30 inches, and the rear wheel 28 inches, with tangent spokes, and hollow rims. It has 6½-inch cranks, 3½-inch rat-trap pedals, ball bearings throughout, and is geared to 105 inches, or as may be desired.

Quadruplets or bicycles adapted to carry four riders are built by the Coventry Machinists' Company Limited, who likewise make triplets and other bicycles adapted for more

* For further description and illustration of this handle-bar, see chapter on Component Parts.

than one rider. The construction of machines for four and more riders only differs, of course, from that of tandems or machines for carrying two riders, in the plan of the framework, which must, naturally, be sufficiently strong to withstand the strains to which it will be subjected when in use. Except for racing purposes, and as interesting examples of what is possible in this direction, these special machines do not seem to be of any utility, nor to be likely to come into any general use.

FIG. 19.—Punnett Sociable Single-track Bicycle or Dicycle.

Quintuplets or quintets, and sextets or sextuplets are simply further elongated varieties adapted respectively for five and six riders. A sextet or sextuplet machine is built by the Fowler Cycle Manufacturing Company, U.S.

SOCIABLE BICYCLES OR DICYCLES.—The objection that has been most frequently raised, and not without reason, against the tandem bicycle, is that, owing to the position of the riders one behind the other, they are very adversely placed for conversation, and that social intercourse which is the primary object for the employment of machines of

this type. Attempts have, therefore, been made to construct a single-track bicycle adopted to carry two riders placed side by side or abreast, as in the old-fashioned sociable tricycles, so as to be more favourably situated for intercommunion. A sociable single-track bicycle or dicycle designed on these lines and constructed by the Punnett Cycle Manufacturing Company, U.S., is shown in Fig. 19. The shape of the frame and the position of the saddles and duplicate driving gear will be clearly seen from the drawing. The extended axle of the rear wheel admits of two chain or sprocket wheels being fixed thereon at a sufficient distance apart to allow of each of them being actuated through a suitable chain from another sprocket or chain wheel upon two separate crank axles carrying cranks adapted to be driven by the riders. There is a triple head, and the frame is duplicated and carries two saddles located side by side at a proper distance apart to admit of two riders conveniently occupying them. The two saddle posts are connected together by a cross bar or tube, centrally in which latter is provided a socket of special construction which admits of one of the saddles being transferred to that position so that the machine may when desired be propelled by a single rider. The machine can thus be conveniently ridden to any place of appointment, to meet the second rider, or in the event of one of the said riders being obliged from any cause to leave the machine, allows of the remaining one either continuing the journey by himself, or riding the machine home again. The machine is not therefore one which depends absolutely upon the presence of two riders.

To mount this bicycle it is first inclined to one side, and one of the riders gets seated upon the saddle at that side to which it is leaning. The machine is then brought back to a vertical position, and the second rider mounts by the pedal, and the start is thus made. To dismount or get off the machine these operations are reversed. It is stated that a difference in weight between the riders of 100 lbs. would not be noticeable or found to cause any inconvenience. An advantage also possessed by this machine is that a tolerably efficient rider can take out a totally inexperienced one as companion without any difficulty. It would, therefore,

seem to afford a good means of imparting confidence to beginners, and of assisting them in learning to ride.

When a saddle is placed in a central position, and the machine ridden by a single rider only, the pedalling must be done on one of the right-hand and on one of the left-hand sets of cranks and pedals. The result of this would of course be the production of a very considerable amount of lost motion in the pedal action. The machine is, therefore, obviously unsuitable for use by a single rider except for short distances or in the case of an emergency.

Another machine, or rather an attachment by which any safety bicycle is capable of being converted into a machine of this class, has been designed by an Italian inventor named Grilli. Shortly, the main feature of Grilli's apparatus consists in the application to a safety bicycle of a couple of half frames, each of which is provided with a seat so arranged that a rider can sit at each side exteriorly to the frame, and they are thus so placed as to balance each other for riding. Pedals for propulsion are provided for, and are operated by each rider, and work a single driving chain. This supplementary apparatus can be adjusted to any high class roadster machine in a few minutes, and detached therefrom at will; and it is stated that experiments have very fully demonstrated that the double weight upon the cycle will be fully provided for by the attachment.

The apparatus admits of a perfect balance being secured mechanically, however unequal the respective weights of the riders may be.

CONVERTIBLES.— In single track bicycles or dicycles, whether adapted for one, two, or more riders, the only convertibility provided is for rendering them suitable for use by either gentlemen or ladies. The usual method of accomplishing this purpose is by providing a detachable top stay. The plan is more usually applied to tandems, but such stays are also sometimes fitted to machines for juvenile ladies or youths.

The machine framework has of course under ordinary conditions, wherein the stay is removed altogether to suit it for lady riders, to be made of sufficient strength to withstand the strains to which it will be liable when in use. For this reason it must be provided with a diagonal stay, and be

constructed as strong as is usual with respect to the frames of ladies' machines, consequently with the addition of the top stay the weight becomes excessive. A better arrangement is that wherein the top stay is pivotally connected or jointed to the top of the steering and removably connected to the saddle pillar. In this case, instead of removing the said top stay when it is desired to change it into a dropped or open-fronted frame, the end connected to the saddle is disconnected therefrom and connected to the bottom bracket, the said stay then forming the usual diagonal brace. The frame in this case can be made as light, or nearly so, as if it were not intended to be convertible for either ladies' or gentlemen's use. It is obvious that a similar hinged or pivoted stay might be advantageously applied to tandems. A machine of this type, with movable top stay capable of being converted to a gentleman's safety at pleasure, is built by Marriot & Cooper.

CHAPTER III.

Modern Tricycles or Three-Wheeled Cycles.

THE Otto, the Welsh, and other two-track bicycles or dicycles, which class of machines are now practically extinct, afforded the advantage of a very perfect distribution of wheel load, the entire weight of the machine and of the rider being upon the driving wheels, and they had, moreover, many other good qualities. Owing, however, most probably to certain difficulties in maintaining, or rather in acquiring, the balance, they never came into very general use. They were by some erroneously classed as tricycles, probably because they possessed a third wheel upon a tail-piece or rearward extension, which only, however, came into operation during an accidental backward spill. From these machines, however, with the two wheels mounted abreast upon the same axle, it was but a very natural step in the direction of securing increased stability, to introduce another or third operative wheel. This led to a very large number of variations in the distribution of the load on the driving wheels, steering wheels, and likewise on the idle or carrying wheels, and consequently about ten years ago very numerous types of tricycles were in use. These machines were very clearly classified by J. Alfred Griffiths * under four principal heads, showing how the three points of support could be arranged with respect to the line of motion through the saddle—viz., class A, wheel triangle with base forward; class B, wheel triangle with apex forward; class C, wheel triangle with apex forward laterally; and class D, wheel triangle with base and apex at sides. Of these four classes, A, C, and D are practically extinct; class B, or that wherein the wheel

* *Proceedings Inst. Mech. Engrs.*, 1886, p. 139.

triangle has its apex forward, being the only one practically in use at the present day, and that in a modified form. It is to tricycles of this class that balance-driving gear was first applied in 1877 by James Starley, who used a modification of a device employed in 1857 by John Fowler & Co. upon heavy steam-traction tricycles, consisting of two bevel wheels facing one another, and each meshing with an intermediate loose pinion.

The seats of tricycles of this type are, as a rule, situated as far to the rear as possible, in order to throw the weight upon the rear-driving wheels and reduce that upon the front-steering wheel. Consequently, whilst possessing perfect stability under the application of the brake, owing to the fulcrum formed by the front-steering wheel, upon which an increased load is imposed immediately upon the application of the said brake, which in turn increases the resistance and assists in checking the driving wheels, on the other hand they are greatly deficient in backward stability.

In the earlier pattern machines of this type the steering or pilot wheel was of small diameter, and they were, in fact, simply tricycles of the class A reversed—that is, with the small trailing wheel, forming the rearwardly extending apex of the wheel triangle in the latter class, placed forward.

The class A, whilst wanting in forward stability, owing to the weight being chiefly upon the front-driving wheels, and being liable to subject the rider to a spill on his face either by running over small obstacles or by the injudicious application of the brake, especially when going down hill, were, on the other hand, possessed of perfect rearward stability for the same reasons that the class B are possessed of an equal degree of forward stability. In order to obviate the possibility of a spill backwards in the first pattern machines of the type B, a fourth wheel was placed at the rear, and they were, in fact, strictly speaking, quadricycles. This fourth wheel, however, was soon found only to come into use when the machine was ridden by an inexperienced or careless rider, and it was consequently first reduced to a small roller normally situated at some distance from the ground, and subsequently to a mere tail support with a knob at its extremity. Later still, the seat was brought sufficiently forward to enable this safety tail to be entirely

done away with, and the front or steering wheel was brought considerably further forward, whereby the increase of load imposed upon the front wheel by the moving forward of the seat was rendered proportionately less, and the said front wheel was also made of considerably larger diameter.

The most usual present practice is to make all the wheels equal, or the steering or front wheel an inch or two larger than the rear or driving wheels. Sometimes, however, the front or steering wheel is made slightly smaller. The carrying forward of the seat, whilst affording rear stability to the machine, would seem to be liable to greatly increase the resistance experienced by the forcing or digging of the fore or steering wheel into the road surface under the action of the additional load superimposed upon it. This load, however, is to some extent relieved when the machine is in use, owing, firstly, to the lifting tendency exercised by the act of driving the rear wheels through the gearing, and secondly, by the supplementary lifting tendency due to the pull upon the handles. This relieving action of the front wheel would be, of course, greatest when the machine was being driven at a rapid rate.

According to J. Alfred Griffiths,* with a tricycle at rest the front load would be about 20 lbs., and if it were prevented from moving a-head, whilst pressure was put on the forward pedal, the front load would be reduced by about 10 lbs. He is of opinion that with such a tricycle when driven by a powerful rider against a maximum resistance, or at such a velocity that the resistance is equal to his strength, the reaction of the resistance would have a similar effect to the holding of the machine, whilst pressure was put upon the forward pedal.

Professor Vernon Boys † is of the opinion that the weight upon the front wheel of a tricycle of this type was reduced by driving, but he considers this to be wholly the result of the lifting action under consideration, and to have nothing to do with the placing of or action on the handles. However the handles might be placed, in his opinion, the same driving

* *Proceedings Inst. Mech. Engrs.*, 1886, p. 143.
† *Ibid.*, 1886, p. 166.

power exerted by a rider in the same position would result in the same reduction of weight on the front wheel.

Fig. 20 illustrates one of Starley Brothers' gentlemen's tricycles of the latest type. It has wheels 28 inches in diameter by $1\frac{3}{4}$ inches wide, and is fitted with their patent combination axle and bridge, and patent central driving gear and gear box. It has a ball head, an improved form of handle-bar and seat pillar, a patent block driving chain, a rubber brake, and ball bearings throughout. The chain is enclosed in a leather case of an improved pattern.

FIG. 20.—Starley Brothers' Gentleman's Tricycle.

The makers claim for this tricycle that it is a truly centrally driven machine, having its chain wheels completely cased or boxed in so that they are thoroughly protected from dust and dirt, and therefore not liable to become damaged thereby. The balance gear being also enclosed in a similar manner, a ready means is afforded of applying a light form of chain guard or cover, by which the entire driving apparatus is enveloped and efficiently protected. The fact of a machine being centrally driven, not only greatly adds to its strength and rigidity, but also admits of the dead weight being still further reduced.

Fig. 21 shows a standard modern type of tricycle built by Humber & Co. Limited. This machine is fitted with 26-inch wheels having tangent spokes and hollow rims or felloes, the outside width of the main axle being 33 inches. It has ball bearings throughout.

Four different patterns of machines of this type are made, viz.—That designed for gentlemen's general use. This machine has $6\frac{1}{2}$-inch cranks, 4-inch rubber pedals, and is geared to 57 inches. It is fitted with a powerful double-action main axle band brake, and has a neat and effective

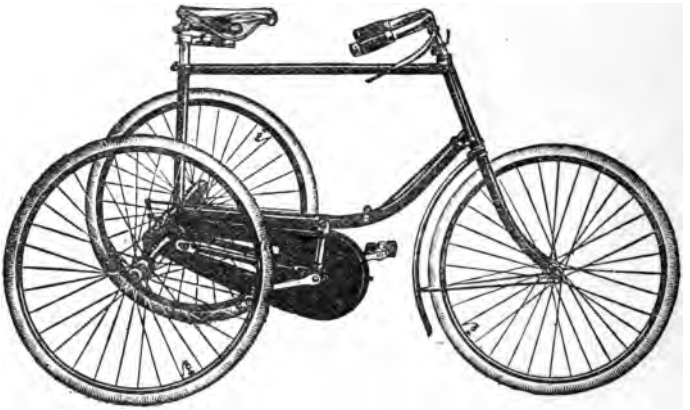

FIG. 21.—Humber & Co. Ltd. Gentleman's Tricycle.

chain wheel guard. The weight of the machine complete is 46 lbs. A lighter machine intended for road racing purposes is fitted with $6\frac{1}{4}$-inch cranks, $3\frac{3}{4}$-inch rat-trap pedals, and is geared to 62 inches. It is fitted with a spring racing saddle, a light completely detachable chain guard and lamp bracket, and weighs complete 32 lbs. The path racer pattern is a still lighter machine. It has $6\frac{1}{4}$-inch cranks, $3\frac{1}{2}$-inch rat-trap pedals, spring racing saddle, and is geared to 65 inches; its weight complete is only 30 lbs. The ladies' pattern is fitted with $6\frac{1}{4}$-inch cranks, special ladies' pedals, patent double-action band brake, leather dress

guard, and is geared to 54 inches. The weight of this machine complete is 47 lbs. A provision is likewise made in the latter machine for the attachment of a top stay tube, when desired, so as to render it fit for use by a gentleman.

Fig. 22 depicts a tricycle built on the most modern lines by the Sparkbrook Manufacturing Company Limited. This machine is fitted with a 28 inch diameter front or steering wheel, and with 26-inch diameter rear or driving wheels, having the best quality tangent spokes, and hollow rims of the Sparkbrook pattern.* The axle is a much improved form of this Company's differential double-driving

FIG. 22.—Sparkbrook Manufacturing Co. Ltd. Gentleman's Tricycle.

type,* which they claim to have practically proved itself to be a perfect balance gear for tricycles. The latest improvement consists essentially in placing the driven gear-wheel in such a position, whilst retaining the differential gear central upon the axle as in the previous patterns, that the machine may be propelled in an exactly similar manner to a safety bicycle, and so enabling a frame like that used for the latter to be employed, which likewise gives the best results for a tricycle as regards rigidity and strength. The

* For description and illustrations of these specialities, see chapter on Component Parts.

frame is of the diamond type, constructed of the well-known weldless brand of steel tubes, and they are of large diameter. The special steel joints and bottom bracket have been already mentioned with reference to the bicycles or dicycles built by this firm. The pedals are either rubber or rat-trap. A central band brake of a reliable type is provided. The driving chain is best block, $\frac{5}{16}$-inch. The machine is geared to 60 inches, or as may be desired, and the weight complete with pneumatic tyres is 45 lbs.

Fig. 23 is an example of the tricycles made by Marriott & Cooper. That illustrated is of the light roadster type, its weight being about 40 lbs. The wheels are 26-inch, with

FIG. 23.—Marriott & Cooper Gentleman's Tricycle.

hollow rims and tangent spokes. The handle-bar is of a flat shape. The cranks have a $6\frac{1}{2}$-inch throw, and the machine is geared to 56 inches. A spoon brake is fitted to the fore wheel in the pattern machine shown in the illustration; but when desired, a band brake upon the driving axle may be substituted. The machine has ball bearings throughout.

An excellent roadster tricycle is also built by the same makers, which is more especially intended for ladies' use, but which might also be comfortably ridden by a gentleman. The framework is constructed of weldless steel tube, and the front wheel fork is hollow. Four bearings are provided to the main axle, and two bearings to the crank axle. The

rear or driving wheels are 30 inches in diameter, and the front or steering wheel is 26 inches in diameter, all fitted with tangent spokes and Dunlop roadster tyres. The cranks are 6½-inch. The handle-bar and seat pillar are adjustable. The machine is likewise provided with a suspension saddle and spring, has plain rubber pedals, a spoon brake, a mud-guard to the front wheel, suitable footrests, and a lamp bracket. The main axle, front wheels, and crank axle are fitted with adjustable ball bearings. The driving gear is of a differential balance type, and is geared to 52 inches.

Tandem Tricycles.

Some few years back these machines were, as in single tricycles adapted to carry one person, constructed in a variety of patterns, every maker nearly having a machine, or several machines, embodying certain characteristic features peculiarly his own. The modern build of tandem tricycle, however, whether adapted to carry the more usual complement of two riders, or three, four, or a greater number of riders, as in the case of triplets, quadruplets, quintuplets, sextuplets, &c., is merely a counterpart of the standard type of tricycle for one rider, with the framework sufficiently extended to allow of room for two, three, four, five, six, or other desired number of seats or saddles placed in line, one behind the other, the chief and most essential point being to so construct the said framing that it will possess sufficient strength and rigidity, without being of excessive weight, to withstand the load it will have to carry, and the shocks, jars, vibrations, and various other strains to which it will undoubtedly be subjected when in use. Machines built on these lines answer sufficiently well in the case of tandems to carry two riders; but for any number above this a trailing or fourth wheel should be added, the machine being then converted into a quadricyle or tetracycle. and being in reality simply a tricycle duplicated, or a multicycle with a central wheel base, and a wheel triangle on each side, one having a central apex to the rear, and the other to the fore—that is, a combination of the two classes A and B.

Fig. 24 represents a pattern of tandem tricycle constructed by the firm whose tricycles for single riders have

just been described. This machine, which is a convertible tandem roadster, has 28-inch driving and 30-inch steering wheels, with tangent spokes. The throw of the cranks is $6\frac{1}{4}$ inches, and both seats and handle-bars are adjustable. The head, side wheel, steering sockets, pedals, and all other moving parts, are fitted with ball bearings. A dress guard or gear case is provided to the front chain, as shown. The outside width of the machine is 36 inches, which measurement can be reduced, by unscrewing one nut, to 30 inches. This machine is convertible at will into a perfect single tricycle.

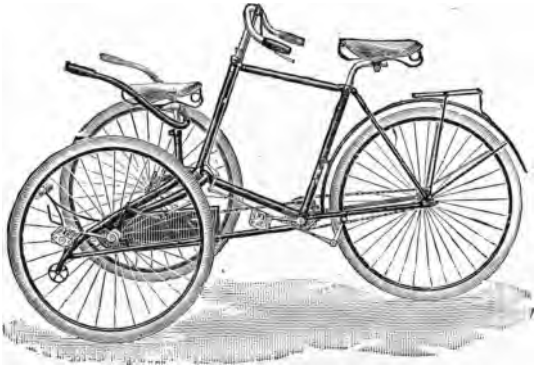

FIG. 24.—Marriott & Cooper Tandem Tricycle.

A similar type of machine, intended more especially for two ladies, but having an attachable stay for enabling the rear seat to be used by a gentleman, is also made by the same firm. This latter machine is fitted with an end-to-end gear case, and both machines are provided with spoon brakes to the driving wheels, and also with band brakes to the side wheels if desired.

A special feature of both these machines is that the front saddle and handle-bars can be removed, and a comfortable basket or wicker-work armchair can be fixed in front. Each of these machines can thus be easily and

expeditiously converted into a light and efficient passenger carrier.

Tandem safety tricycles are made by a number of other makers. The main features of all, however, remain practically the same, the improvements consisting principally in details of construction.

In a machine, for example, designed and built by the Coventry Machinists' Company Limited, the rear or driving wheels are 28 inches in diameter, and the front or steering wheel is 30 inches in diameter. The wheels have hollow rims or felloes and tangent spokes. The framework is constructed of specially selected weldless steel tube, and is strengthened or reinforced wherever it may be necessary by serrated bushes. The cranks are 6½-inch throw, and readily detachable. The tread is very narrow. The saddle and handle-bars are adjustable, are arranged for an easy and comfortable position, and a new patent combination steering and machine lock is provided. In this latter device, by means of a simple arrangement, the steering post can be at once locked, and by putting in addition a secret combination into play, it cannot be then unlocked, except by some one conversant with the right mode of doing so. The steering consists of a new patented duplex head and steering column,* which arrangement is claimed to greatly increase the strength of this vital part. The driving gear is interchangeable and easily detachable, and the best quality of block tandem chains are fitted, ample provision being made for independent chain adjustment and chain case clearances. This machine is made in three types—viz., the roadster, road racer, and path racer—the first being fitted with powerful rubber-covered spoon brake, detachable mud-guards, step, and lamp bracket. The bearings are lapped to gauge, and balls are provided to all parts, including socket steering and pedals. The roadster is geared to 65 inches, and the racers to 84 inches, or as may be desired.

Another tandem machine by the same makers has a drop front for a lady. In other respects this machine is practically the same as that just described as a roadster for two

* For description and illustration of this device, see chapter on Component Parts.

gentlemen. A leather case is fitted, however, over the front chain and chain wheel. The open front for the lady is of the loop pattern, and allows ample clearance or space for the dress. A similar machine to the above, but arranged for two ladies, is also made.

Sociable Tricycles.

Some nine or ten years ago the common type of tricycle for carrying two riders was the sociable, wherein the riders were placed abreast or side by side, which position, as already remarked with reference to sociable bicycles or dicycles, is far more calculated to promote pleasant companionship, and to foster that social intercourse which is one of the chief inducements to the use of machines for carrying more than one rider. These machines have now, however, become practically extinct, and superseded by those of the tandem type, which have been illustrated and described in the previous section. Most of the old sociable tricycles were so constructed as to be convertible at will into single machines.

CHAPTER IV.

CARRIERS.

MACHINES of this class may be divided into—First, Those adapted for the conveyance of passengers—that is to say, persons who themselves take no active part in the propulsion of the vehicle, but are propelled by one or more other riders either by means of foot power, through cranks and gearing, or by manumotive power. Second, Those intended for the transportation of goods, wherein a portion of the machine is suitably arranged for the reception of the said goods, whilst the propulsion is likewise effected by one or more riders in a like manner. The use of machines of the first class has not yet become common, but those of the second class are extensively patronised by tradesmen, and the demand for them is extending daily.

In Paris the cycle has been adapted as a fire-engine, and is said to give satisfactory results. The apparatus consists of a light frame mounted upon four wheels, which frame supports a pump, and is also arranged to carry the reel and hose, &c. The machine is ridden to the scene of the fire by a couple of firemen, being driven by chain gearing in the usual manner, and when in position, and the hose having been adjusted, the gearing can be so altered as to admit of its being used to work the pump. The combined efforts of the two men will, it is stated, force a jet of water 90 feet high.

PASSENGER CARRIERS.—The term passenger carrier may be understood to mean a class of tricycle specially constructed, as above intimated, for carrying a passenger who remains perforce inactive, so far as any assistance to the propulsion of the vehicle is concerned. Any cycle almost

that is adapted for the accommodation of two or more riders might obviously be employed for such a purpose, as the driving might be left entirely to one of the riders in the case of a tandem, or to any other number in the case of a triplet or quadruplet, &c.; but the term is usually accepted as meaning machines especially constructed for the purpose.

The idea is by no means one of recent date, for, according to Robert Edward Phillips,* a bath chair, propelled by a rider, has been described by Jacques Ozanam, in a French work entitled "Recreations in Mathematics and Natural Philosophy," published as far back as 1670. A very successful machine of this type was introduced about ten years ago in this country. This machine, which was known as the "Coventry Chair," consisted of an ordinary Bath chair to accommodate the passenger, the large wheels of which chair had been removed and were replaced by a tricycle frame, having a pair of driving wheels, and fitted with ordinary pedal and crank driving gear. A suitable seat for the rider, whose duty it was to propel the machine through the said pedals and cranks, was provided at the rear.

Although these machines, as primarily constructed, were very cumbersome, and far too heavy, it is stated that one of them was driven from Coventry to London, a distance of ninety-five miles, with a passenger and 50 lbs. weight of luggage, in twenty-two hours.* Another is said to have been driven from Walsall to Rhyl, which latter place is 110 miles distant from the former, in 24½ hours. In this instance the passenger weighed 10 stone, the driver 14½ stone, and 60 lbs. of luggage were carried.†

Considering the very great convenience and the comparatively high speed that can be attained by a vehicle of this description, especially for making short journeys on good roads, it is somewhat surprising that they have not come into more general use. One would imagine that in towns they might with advantage, to some extent at least, take the place of cabs for conveying a single passenger expeditiously from place to place, within, of course, reasonable

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* *Proceedings Inst. Mech. Engrs.*, 1885, p. 494.
† *Ibid.*, 1885, p. 495.

limits as to distance. One reason, no doubt, for their not becoming more common is that a machine thoroughly suitable for this work has yet to be designed and built.

GOODS CARRIERS.—These are now extremely numerous, and comprise various patterns, suitable for a variety of different purposes. Those most in use are especially designed for parcel post delivery, and in rural districts letter deliveries, for newspaper distribution, and they are also constructed for butchers, bakers, druggists, and in fact for almost every trade.

The chief point to be aimed at in the design of a parcel or goods carrier is to balance as much as possible the load upon the driving wheels, and upon the greater or less perfection with which this is effected depends their efficiency. The other features are principally details of construction, designed to render them suitable for the work they are intended to perform. The majority of goods carriers are tricycles or three-wheeled velocipedes, a seat being provided, usually about centrally between the front driving axle and the goods receptacle, for one rider, who has to work the driving gear and propel the machine. For machines of greater capacity, however, such as parcel post vans intended to carry a considerable number of parcels, and other large machines for the distribution of goods, it is frequently desirable to employ two or more riders, whose combined efforts will propel the vehicle. In these cases the receptacle for the goods is usually mounted upon four wheels, and these machines are consequently quadricycles or tetracycles.

In an apparatus intended more especially for postal service, patented by John Warrick (No. 13,081 of 1891), two riders placed directly in line, and facing each other, propel and steer the machine. The essential features of this carrier are as follows:—As usually constructed, the seat for the driver is, as already mentioned, placed midway, or thereabouts, between the driving axle of the two front wheels and the carrying receptacle. In the present example, the second seat is placed in front of the driving axle of the said two front wheels, so as to balance the other seat, the riders facing each other. The driving pedals are arranged in two heights for the foot of each man, or so as to receive

the two feet—one alongside the other—both men consequently driving on to the same axle.

In a modification of the above-described machine, wherein greater driving power is said to be obtained, the tubular frame is extended in a forward direction beyond the two front or fore driving wheels, and upon this extension is mounted a saddle or seat, arranged so that the second rider may sit facing the same way as the first or other rider. For driving purposes cranks and pedals are in this case mounted at or near the end of this projecting portion of the frame, and they are connected to the driving axle of the front wheels by means of chain wheels and pitch chain, or otherwise. To increase the stability of the cycle, and to enable a heavier load to be carried, two rear or steering wheels are provided. These latter are so mounted as to be free to revolve separately, so that one may be capable of rotating faster than the other when running round curves in turning corners, &c. The two rear-steering wheels, which are of small diameter, are capable of being turned together for steering purposes by the same fork. Both of the riders have control of the steering through two ordinary spade-pattern handles, each fixed on the top of a vertical rod, at the lower end of which is a pinion gearing into a rack fixed to the steering rod. The receptacle for the goods is carried upon spiral springs, so as to reduce the jolting, and consequent damage to the contents, that might otherwise be caused by the inequalities of the road surface.

It is said that this cycle is capable of carrying any load up to six hundredweight, and that when so loaded it can be easily propelled by two riders on ordinary roads, where the gradients are not excessively steep.

The second arrangement, or that wherein the two riders are mounted both facing the same way, is found to be the most efficient in practice.

In Fig. 25 is illustrated a front-driver parcel-carrying machine, built by Messrs Singer & Co. Limited. As will be seen from the illustration, this carrier consists of a front-driving tricycle, the receptacle or box being situated over the rear axle, and the saddle for the rider in a convenient position to enable him to work the driving cranks on the front-driving wheel, which is fitted with the "Crypto"

driving gear.* An advantage claimed for this machine is its extreme simplicity, and the ease with which adjustments of the parts can be made. The substitution of a geared driving wheel for the chain driving enables the latter troublesome part to be dispensed with.

Usual dimensions for this carrier are: 28-inch wheels, and a body receptacle or box, 30 inches in length by 28

FIG. 25.—Singer & Co. Ltd. Front-Driver Parcel-Carrying Machine.

inches in width, and 21 inches in depth, made thoroughly waterproof, and fitted with a rear door. Adjustable ball bearings are provided to all the running parts.

With this carrier 80 lbs. weight of goods can be transported upon average surfaces with ease, the machine being only worked by a lad.

* For description and illustration of this gear, see chapter on Component Parts.

CHAPTER V.

MISCELLANEOUS MACHINES.

THE miscellaneous forms of cycles having more than three wheels, and less than two wheels, and driven in various ways, that have been devised from time to time, are very numerous, and it will only be possible to here give a very brief outline of a few typical machines.

Regarding cycles having more than three wheels, it may be remarked that those with four wheels are universally known as quadricycles or tetracycles, and a usual classification of such machines as have more than four wheels, and one adopted by the Patent Office, is to group them under the head of multicycles, although why they should be any more multicycles than quadricycles or tricycles seems hard to conceive. Altogether it may be said that the terminology of cycles is rather inaccurate. Railway companies classify all cycles under the two heads of tricycles and bicycles; and when the Otto was in use it was termed a bicycle, in which the two wheels were placed side by side, which was of course a perfectly correct definition, but somewhat lengthy. Some writers christened the latter class of cycles dicycles, which they also undoubtedly are, but no more so than any two-wheeled single track cycle, with the wheels placed in line one behind the other.

Dicycle, indeed, as has been previously remarked, is the true and proper name for cycles of the latter class, and not the mixed-up word bicycle, which has now become commonly accepted as the proper name for all two-wheeled cycles.

QUADRICYCLES OR TETRACYCLES.—About ten years ago cycles having four wheels were very common, and different patterns were constructed by various makers. Amongst

those best known mention might be made of the "Coventry Convertible Sociable," the "Royal Mail," the "Club," the "Carver," and the "Quadrant," all of which are three track machines adapted for carrying two riders. The "Humber-Cruiser" was a four equal-wheeled two-track tandem cycle, and consisted of a Humber and a Cruiser machine connected or coupled together by a specially designed swivel coupling bar. At present quadricycles are almost extinct except for heavy goods carriers, upon which this number of wheels is not uncommon—as, for instance, the tandem parcels post delivery machine, described in the previous chapter.

MULTICYCLES.—An example of a pentacycle or five-wheeled cycle was found in Gibbon's combination three-track tandem, which consisted essentially of a machine with a small rear trailing wheel of the class having the base of the wheel triangle placed forward, with a similar tricycle, with its trailing wheel removed, coupled behind. Many examples of this class of cycle might be given, but as they do not differ in principle of construction to any material extent from that of other machines having four or three wheels, but merely in certain specific details, and as, moreover, they are not of any general interest, it would be idle to enter more fully into descriptions of examples of these many wheeled cycles.

UNICYCLES OR MONOCYCLES.—Attempts have been made for a great many years to produce a unicycle or monocycle—that is to say, a cycle having only one wheel, that would be a success from a practical point of view. Hitherto, however, this type of cycle has been a most unqualified failure. Nevertheless the plan has several very obvious points of merit about it. For instance, it presents by far the most feasible method of ensuring a practically perfect distribution of wheel load.

The chief drawback to unicycles or monocycles is their great instability both fore and aft, and laterally, whereby the riding of them is rendered so risky as not to be capable of being undertaken by an ordinary pleasure rider.

In machines of this class the rider is either so placed as to be seated at or about the centre of a large wheel, or else

so as to be astride of a smaller wheel. The driving is usually effected by the operation of hand cranks, the feet being supported idly on rests or in suitable stirrups, or otherwise, but in some cases the wheel is driven by means of cranks and pedals.

Fig. 26 illustrates a monocycle or unicycle, driven according to the first-named method. The saddle or seat A is supported by a frame having arms or projections B, terminating in suitable wheels or rollers C. These rollers C

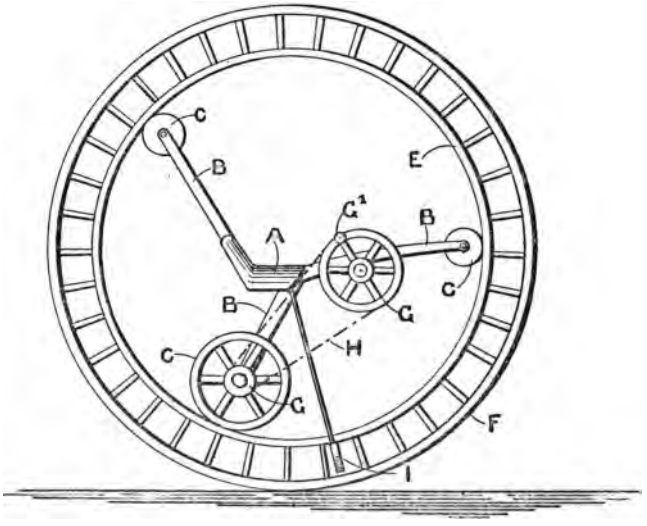

FIG. 26.—Monocycle or Unicycle.

are arranged to run upon a path or race D, formed upon the inner side or surface E of the rim or felloe F of the large wheel. G is a hand wheel or pulley rotatably mounted upon the frame B, and intended to be driven by crank handles G^1. From the hand wheel or pulley G, belts or bands H pass round another pulley G, fixed upon the axle of the larger one of the rollers C, by the rotation of which propulsion is effected through friction with the surface of the path or race D. The remainder or smaller rollers C act only as

guides to retain the central mechanism in position. 1 is one of the stirrups for supporting the rider's feet, and keeping them off the ground whilst the machine is travelling.

To steer this cycle, either the rider removes his foot from the one stirrup or the other, and by touching the ground, therewith turns or slews the wheel to one side or the other, as may be required, or else, for slight deviations only, he may effect the steering by inclining his body laterally to the one or the other side as required.

Fig. 27 shows a sociable monocycle or unicycle, designed in 1881 by an inventor named Pearce. As will be seen from the illustration, a seat A, and driving gear B, is provided at each side of the wheel C. The seats A are mounted upon extensions of the shaft or axle, to which are also attached suitable handle-bars and downward extensions supporting the pedal axle brackets. The pedal axles have mounted upon them chain or sprocket wheels, which are geared through suitable pitch chains with chain or sprocket wheels provided upon the hub of the wheel.

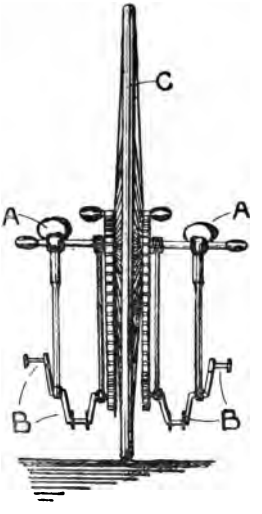

FIG. 27.—Sociable Monocycle or Unicycle.

A unicycle or monocycle was also invented by H. C. Tucker, and patented in 1888, wherein the rider is placed on the top of the wheel, and the driving effected through suitable hand cranks. The rider's feet are normally supported upon side pieces attached to the framing.

Kolb's unicycle, patented in 1890, is somewhat similar to that shown in Fig. 26.

MANUMOTIVE OR HAND-POWER VELOCIPEDES.—Many of the cycles of the preceding type might be classed under this head, being usually driven by hand-power. Numbers of machines having two or more wheels, and designed to be driven by this means, or by a combination thereof with

foot power, have likewise been brought out. As a general rule, however, hand-power machines cannot compete, either in speed or facility of propulsion, with those driven by foot-power, and they are therefore chiefly valuable for special purposes.

Baron de Drais' bicycle of 1821 was, as already mentioned, driven by a hand lever and rack and pinion gearing, assisted by alternately touching the ground with the feet or tip-toeing. Numerous tricycles, or, as they used to be termed, velocipedes, were subsequently designed, wherein propulsion was effected by hand cranks, levers, or other manual power, in some machines the steering being effected through the feet by means of stirrups attached to cords leading to the rear or steering wheels. Some bicycles or dicycles were arranged to be worked by a combined action of the hands and feet through suitable connecting rods between the cranks fitted to the axle of a large front wheel, and hand and foot levers. More recently many attempts have been made to produce a practical machine of this type.

Amongst the former machines, a tricycle known as the "Velociman," brought out some ten years back, was especially designed to meet the requirements of those dependent upon their arms, or chiefly so, for effecting the propulsion of the machine. The driving wheels were mounted upon a differentially geared axle, which latter was driven by a pair of hand levers through a cranked countershaft and chain wheels and chain. The above-mentioned hand levers were connected to a rocking frame, which latter was itself pivoted to the main frame, and it was likewise provided with a footboard, so that when possible the legs might be also used to propel the machine. A pad was provided behind the rider by leaning the back against which the steering could be effected. A modern type of this machine will be found illustrated and described at the end of this section.

Another machine which came out about the same time as the above was that invented by a clergyman named Taylor, which was called the "Oarsman." It had two driving wheels rotatably mounted upon their axle, and a rear wheel by which the steering was effected. The propulsion was operated by cords, which actuated suitable clutches

secured to the driving wheels, the said cords being passed round the drums of the said clutches, and over grooved guide pulleys or wheels rotatably mounted upon the fore part of the machine framing, and which cords were secured at their other extremities to a sliding and rocking frame, upon which was placed the seat for the rider. To propel the machine these cords were pulled in a backward direction by means of a crossbar attached thereto, whilst at one and the same time, under the action of the legs, the sliding seat was also moved backwards. Upon the seat being slid forward again for the next stroke, the clutch boxes were also returned to suitable positions under the reaction of coiled springs, which had become compressed during the previous stroke. It will be seen that the action is similar to that exercised in rowing, and the greater portion of the strength of the body can be utilised.

In a patented (1883) form of cycle, invented by M. T. Quevedo, the machine is so arranged that it can be propelled by levers in the hands of the rider, the action of which is similar to a pair of oars.

Fig. 28 shows the revised up-to-date pattern of the "Velociman" for 1896, made by Singer & Co. Limited. It will be seen that the essential features of the machine have been retained; and indeed for a tricycle of this type it would not seem possible to improve upon them. The arrangement by which both levers are pulled simultaneously, as in rowing, certainly enables the rider to use all his power to the best possible advantage. The method of steering consists in leaning the back against the rest or pad shown at the rear of the seat (which rest is connected to the small hind trailing steering wheel by means of an adjustable arm), and moving or twisting the body to one or other side as may be necessary. Slight movements are all that will be required for the ordinary exigencies of steering, but when it is desired to turn the tricycle round, the steering may be moved through a greater angle by hand. This later type of machine is provided with two front extensions, carrying small guard or safety wheels, which come into use only should the machine be tipped forward. A powerful band brake is fitted for controlling the machine on down gradients. The foot rests are adjustably mounted upon the extensions

carrying the guard or safety wheels, and an auxiliary foot motion can be fitted to the machine when required. This tricycle can be easily propelled by the arms alone at a speed of from six to eight miles an hour.

ICE VELOCIPEDES.—The most common form of cycle for travelling upon ice consists of a machine resembling one of the old ordinaries, the large front driving and steering

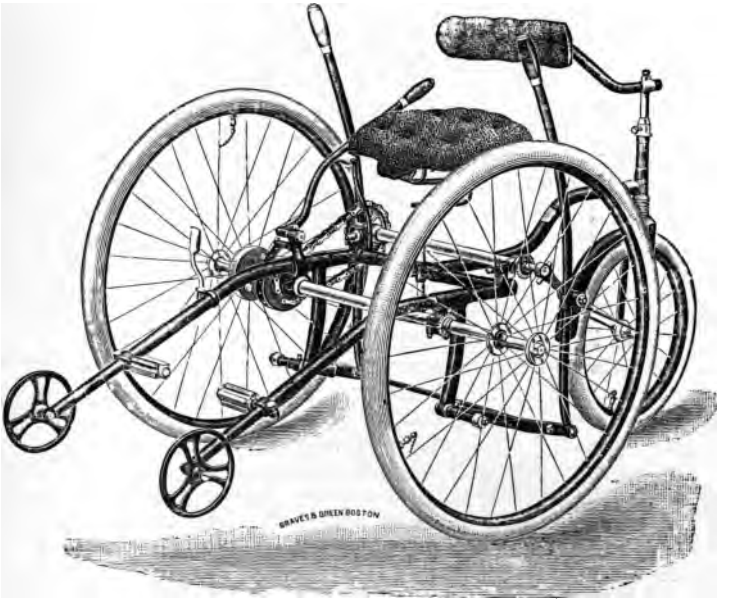

FIG. 28.—Singer Manumotive or Hand-power Velocipede.

wheel, however, being provided with spikes or projections to obtain a grip upon the ice, and the rear or trailing wheel being replaced by two runners or blades. The steering is effected by a handle-bar in the same manner as the ordinary land cycle.

WATER CYCLES.—In one type of machine of this class the driver or drivers can operate a suitable paddle wheel by

which the propulsion of the boat will be effected. In another the said driver or drivers can actuate a shaft carrying a screw or propeller, or work a centrifugal or other pump or pumps, for a like purpose.

A common arrangement on the first principle is a main paddle wheel, which is rotatably mounted in the centre line of the boat, but slightly astern, in a suitable casing, through which casing it passes below, and dips into the water. Upon the upper part of this casing is a seat upon which the driver sits so as to bestride the said casing and the contained paddle wheel, and drives the latter by operating cranks secured upon the projecting extremities of the shaft or spindle. The steering of the boat is effected by means of cords attached to the rudder-head, and passing beneath grooved wheels or pulleys to a steering bar or head placed within a convenient distance from the driver.

An arrangement wherein the driver operates a screw-shaft is exemplified by Vajork's foot-motor boat. In an arrangement of this description intended for three drivers or operators, a suitable framework of light tube, somewhat similar to that of a triplet bicycle or dicycle, is secured about amidships upon brackets or standards fixed to the bottom of the boat. Upon this framework are mounted three saddles, in front of each of which is provided a fixed handle-bar for forming a support for the driver or operator. Beneath the upper bar or stay carrying the saddles is rotatably mounted a crank shaft, which can be driven by the operators through suitable connecting rods and treadles. The rear extremity of this shaft carries a chain or sprocket wheel, which is connected with and drives another chain or sprocket wheel upon a screw or propeller shaft placed in the bottom of the boat, through a suitable pitch chain. The steering is intended to be effected by the cockswain from the stern of the boat in the usual manner; but it is obvious that the tiller lines might be conducted to a steering bar or head, capable of being operated by one of the drivers or operators, preferably the one placed nearest the stern. The arrangement of the cranks is such that dead centres are avoided, and for each sixty movements of the treadles the screw or propeller will make some five hundred revolutions. It is stated that even comparatively

unskilled operators can easily attain a speed of five miles an hour with this boat. The apparatus can be readily fitted to any boat having sufficient width of beam. When desired, moreover, the boat can be propelled by oars or under sails in the usual manner.

It will be obvious that in both this and the first described arrangement the operators are placed so high that due provision for preserving the stability of the boats must be resorted to. The usual and obvious plan for effecting this purpose is to place a sufficient counterweight of lead in the keel.

Another method which has been also used with some success on steam canal boats, &c., is to utilise the rotary motion obtained on the crank shaft to drive a centrifugal or other pump, which is so arranged that it will discharge at the stern of the boat, and so propel the latter in a forward direction through the water. It is obvious that by employing two pumps, each with a separate outlet, or so arranging the discharge from the single pump that it will have a double outlet, each outlet being in both cases separately governable, the propelling medium (*i.e.*, columns of water) can be also used for steering purposes.

CHAPTER VI.

Efficiency of Cycles.

THE efficiency of cycles is intimately connected with the particular purposes for which they are intended, viz., racing, general use on ordinary roads, and for carrying passengers or goods. The points of efficiency applying to cycles generally, as laid down some years back by Griffiths,* and which have been already briefly alluded to, are *in extenso* as follows, and they are equally applicable at the present time as they were when drawn up by that gentleman :—

1. Reduction of dead weight by the avoidance of very large wheels, and of heavy or purely ornamental or unnecessary framing.

2. Reduction of resistance by avoidance of very small wheels, and by employment of the best designs in bearings, and in driving mechanism for the diminution of internal friction.

3. Perfection of load distribution by entire avoidance of wheels that neither transmit motive power nor assist the steering, and by concentration of the load on the driving wheels, and reduction of that on the steering wheels.

4. Stability when in motion both on the straight and round curves; when on a smooth surface, and also on a rough and lumpy road; and when the brake is applied either suddenly or gradually.

5. Arrangement of load and driving mechanism, so that the distribution of the wheel load shall be as good on rising or falling gradients as on a level.

Some authorities upon cycles hold, that, whilst a given

* *Proceedings Inst. Mech. Engrs.*, 1886, p. 131.

weight added to the machine forms a serious impediment to propulsion, the same weight carried by the rider is practically no hindrance thereto. However this may be,—and there do not seem to be any satisfactory grounds for the theory,—it appears to be pretty certain from observations made by many independent riders, that a given amount of weight added to the wheels is immediately felt by the rider in the increased labour entailed to drive, whereas on the other hand the same weight added to, and distributed over, the framework becomes practically unnoticeable.

The dynamical aspect of the subject, that is the variation of the load in accordance with the driving action,—a question of the utmost importance, and one which arises the instant that a cycle is put in motion,—has been very clearly explained by Prof. C. Vernon Boys,* as follows. "The distribution of the wheel load would of course be affected both by the gradient and by the rider's position, and would therefore vary from time to time; and whatever position the rider might assume, and whatever gradient the machine might be on, the distribution of wheel load could be easily found, provided the rider were not driving either forwards or backwards, and were not applying the brake. Mere statical considerations would under these conditions be sufficient to determine the distribution. But as soon as the rider drove or stopped the machine, dynamical considerations presented themselves. When the rider applied force to either of the treadles, and so tended to turn the main axle, or when by the brake he tended to stop the motion of the main axle, the rider and the frame combined were in effect one body, and the axle was another, and the force between them was of the nature of a couple. Whatever turning force was applied to the axle, an equal and opposite turning force reacted on the frame, thereby altering of course the distribution of wheel load. For example, taking 31 inches as the wheel-base of a bicycle,† and 5 inches as the length of a crank, if the rider pressed either treadle with a force of 180 lbs. at right angles to its length, the couple would be 900 inch-lbs., which was equivalent to 29 lbs. acting on an arm

* *Proceedings Inst. Mech. Engrs.*, 1886, pp. 164-166.
† Old "ordinary" front-driving bicycle.

of 31 inches; so that 29 lbs. was the increased weight on the hind wheel, if the rider was forward treadling, or on the front wheel, if he was back treadling. That would be an increase over what the weight would be if the rider and machine were to assume precisely the same position, but without the application of the driving force of 180 lbs. If the position was such that without this force there was not so much as 29 lbs. on the rear wheel, then back treadling to the extent indicated, or an equal backward pull with the brake—no matter which—would raise the hind wheel from the ground. The same considerations applied exactly to machines with gearing, in which it was of no consequence how the turning force was produced, whether by a strong push on a high-geared machine, or by a less strong push on a low-geared machine. Whatever couple was produced at the driving axle, as the result of the action of the rider or of the brake, that couple would always act on the frame, and so disturb the load distribution in the manner already shown."

Distribution of Wheel Load in Bicycles.

In dealing with bicycles or dicycles wherein the wheels are placed in line, the main point to be determined is the proper distribution of the wheel load, to ensure perfect or practically perfect fore and aft stability. As regards lateral stability it might be here mentioned that the gyroscopic action of the wheels in this class of machine increased their lateral stability in running round curves, whilst on the other hand in tricycles and other multi-track machines it reduced the said stability.

The most perfect distribution of wheel load in cycles is, as has been already mentioned, that attainable in unicycles or monocycles, but their instability in all directions obviously renders the balancing and riding of them a matter not only of considerable difficulty, but one accompanied, even to the expert, with no little danger.

In a bicycle or dicycle having two wheels arranged to run in the same track, and wherein the front wheel was the driving wheel, and was fitted with the cranks, it was found that, in order to ensure freedom from slipping or skidding, the rider's weight had to be placed chiefly upon the said

front wheel, as has been already mentioned on page 5. Such a machine was the high ordinary, illustrated in Fig. 3, page 7. In the diagram, Fig. 29, the dotted lines drawn from a point situated 4 inches above the centre of the upper surface of the saddle, which point is taken as the centre of gravity of machine and rider, to the wheel base, indicate the distribution of the wheel load in this bicycle or dicycle. It is obvious from the steepness of the lines from the centre of gravity to the front and rear wheel base, that it is a most dangerous vehicle, as indeed it abundantly proved itself to be, and one through accidents caused by which many lives were lost, and still greater numbers of persons were more or less seriously injured. When descending a steeper gradient

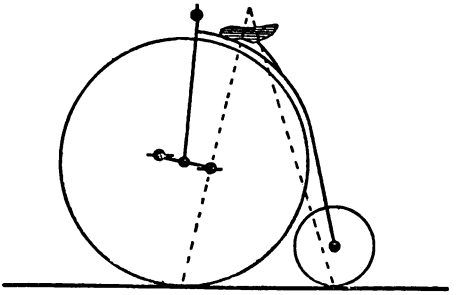

FIG. 29.—Diagram showing Distribution of Wheel Load in "Ordinary."

than one in twenty, indeed, a rider of one of these machines could only save himself from falling forward by leaning well back. Whilst even on a level surface, when running at any degree of velocity, any slight obstruction such as a small stone or a rut by which the large fore wheel would be checked, or the sudden or injudicious application of the brake, when fitted in connection with the fore wheel, would cause the rider to go over the front wheel base upon his head. The avoidance of accidents of this kind was only to be effected by constant watchfulness and care, and at night time even with the most careful riding, their occurrence was practically an ever-present contingency.

The stability of many of the so-called safety bicycles or

dicycles, which were introduced about 1885 in order to overcome this objection, was obviously not to any great extent in excess of that of the high ordinary, and the term safety as applied to them was undoubtedly a misnomer. Fig. 30 is a diagram showing the fore and aft stability of the "Club"

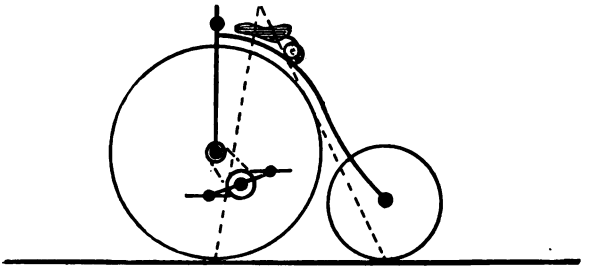

FIG. 30.—Diagram showing Distribution of Wheel Load in "Club" Safety.

safety which is shown in Fig. 4, and which is not, so far as forward stability is concerned, greatly in advance upon the ordinary. In some few instances, however, the rider's weight

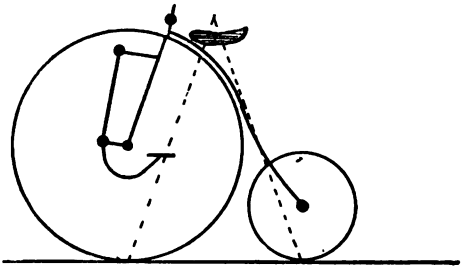

FIG. 31.—Diagram showing Distribution of Wheel Load in "Xtraordinary" Safety.

was placed sufficiently to the rear to obviate any danger of the rider taking headers over the front wheel base, except under circumstances of an exceptionally phenomenal nature. A good example of a cycle of this type is afforded by one in use some ten years back, which was known as the

"'Xtraordinary," and wherein, as will be seen from the diagram (Fig. 31), the front line of the triangle from the rider's centre of gravity down to the fore wheel base is greatly more slanting than that of the ordinary (see Fig. 29). This would admit of the front wheel coming in contact with a small obstacle, or of the brake being put full on, without the resultant header over the fore wheel that was the inevitable result consequent upon the above actions in the case of the ordinary.

Front-driving bicycles, with the exception of special machines, which are fitted with multiplying gear, and some of which have certain important specific advantages, are

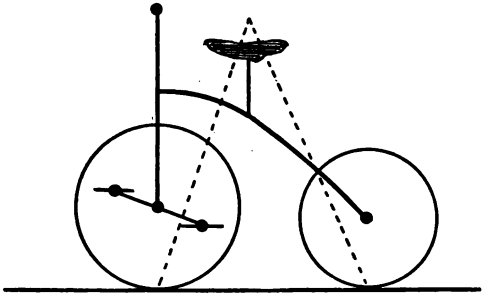

FIG. 32.—Diagram showing Distribution of Wheel Load in "Bantam" Safety.

practically extinct. The most used of these is that known as the "Bantam" (Fig. 10), which is made by the Crypto Works Company Limited. This machine is possessed of many good qualities, which will doubtless ensure its retaining its position as a prime favourite for certain classes of work for some time to come. It has the name of being, and indeed is, a thoroughly comfortable machine for pleasure riding, and is particularly suitable for elderly persons—a not inconsiderable advantage even to the practised rider of a certain age being that it can be readily mounted without a step, whilst to those learning the art it affords the great desideratum of allowing the ground to be easily tiptoed. In fact, the machine can be used at first in

a similar manner to an old hobby-horse, and the necessary confidence is thus easily attained. The increased liability to side slip on greasy roads, owing to the small diameter of the wheels, is so slight as not to form a factor of any importance; and the more rapid destruction of the tyres from the same reason is counteracted and practically nullified by the increased width thereof. As regards fore and aft stability, the machine is about equal both ways, and practically as safe as any rear-driving safety bicycle or dicycle. Fig. 32 shows the distribution of wheel load in a geared front-driver of this type.

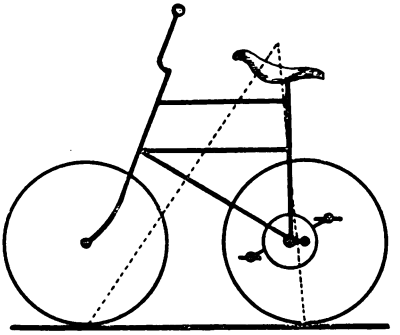

FIG. 33.—Diagram showing Distribution of Wheel Load in "Cyclet" Safety.

The rear-driving geared chainless bicycle or dicycle, known as the "Cyclet," shown in Fig. 9, whilst affording ample margin of safety against a forward spill, is somewhat wanting in rearward stability, as will be seen from a glance at the diagram, Fig. 33, showing the distribution of the wheel load in this cycle.

The stability of the present type of rear-driving safety bicycles or dicycles approximates to that of the old hobby-horse, and the first development thereof, known as the bone-shaker, to which latter class they evidently belong, having however, a somewhat different distribution of wheel load. As will be seen from the diagram, Fig. 34, the rear-driving safety

has a practically perfect fore and aft stability, owing to the position of the rider between the two wheels, and the point at which power is applied for driving. The wheels of rear-driving safety bicycles are medium sized, and either of equal diameter, or the front or steering wheels are slightly larger. The employment of a larger front wheel reduces the resistance, increases the steadiness in running, by reason of its greater gyroscopic stability facilitates the steering, and, moreover, renders the liability to side slip far less. The load distribution in cycles of this type causes a great re-

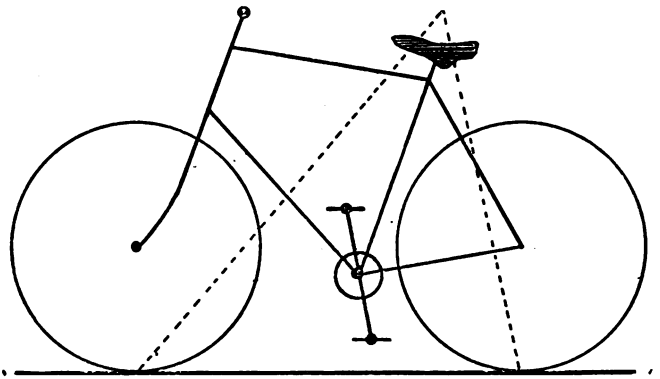

FIG. 34.—Diagram showing Distribution of Wheel Load in Rear-Driving Chain Safety.

duction in vibration as compared with those wherein a certain portion of the load is carried on a small wheel without the interposition of any spring or elastic buffer arrangement.

EFFICIENCY OF THREE-WHEELED CYCLES OR TRICYCLES.—Cycles of this class, wherein an attempt has been made to increase the stability by the addition of a third wheel, were, a few years back, constructed in such a variety of patterns that the distributions of wheel load were very numerous, viz., on the driving wheels, on the steering wheels, and on

idle or carrying wheels. The present type of tricycle, however, which is practically similar in design to a standard pattern bicycle, with the exception of the duplication of the rear wheel, and the necessary modifications entailed by this additional wheel, has about the same distribution of wheel load. In some types, however, the seat or saddle is taken farther to the rear than in others, and the load chiefly placed upon the rear or driving wheel. The efficiency of the machine is thus slightly increased, but at the expense of considerable loss of rearward stability. These tricycles are all three-track machines and of the class B—that is to say, those wherein the wheel triangle has its apex forward. A glance at any of the standard cycles of this class (Figs. 20-24) will show that the machine was evolved from one of the earlier patterns of tricycles, such as the "Quadrant" or the "Cripper," which bore a similar resemblance to the early rear-driving bicycles, with small steering wheels, that the present tricycle does to the standard pattern of rear-driving safety bicycle, with either equal or slightly larger front or steering wheel.

ADJUSTMENT.—The cycle, whether constructed with one wheel only, as in the unicycle or monocycle, or with two or more wheels, as in the case of the bicycle or dicycle, tricycle, quadricycle, &c., is eminently a machine adjusted for and suitable for running on the level. Any variation in the gradient of the surface upon which a cycle is running immediately alters the distribution of the wheel load, and to a greater or lesser extent disturbs the stability of the rider. In modern cycles, it is true, this occurs to a much lesser extent than it did in those of earlier patterns, but it is still present, and constitutes an important point when considering their stability, more especially with respect to machines intended for general use upon roads where the gradients are different every few yards, and whereon level stretches of surface are the rare exception.

In earlier times attempts were made to remedy this defect by the provision both in bicycles or dicycles and tricycles of arrangements whereby the rider could himself operate adjustment of the seat or saddle, through a lever or other means, with greater facility than could be done by shifting the said saddle fore or aft upon the usual ⅂-shaped pin, an opera-

tion that would of course entail constant dismounting, and more or less troublesome slackening of clips, &c. There were also adjustments whereby the rider's position would be automatically altered to suit the gradient upon which he might happen to be placed.

Amongst these adjustments may be mentioned that invented by F. W. Jones, and applied to a dwarf safety bicycle, and to a tricycle which was known as the "Devon," and which consisted of an adjustable double frame.* An adjustment through a swinging seat-pillar was devised by J. A. Griffiths, and applied to his "Kaiser" safety bicycle, and an automatic adjustment also designed by the latter gentleman was applied to his "Spinaway" tricycles. In the "Kaiser," the rider's position was adjusted automatically to the gradient by the above-mentioned swinging seat-pillar, by which means the saddle was disconnected from the main frame. This swinging seat-pillar was hinged or pivoted at its lower end as near as practicable to the treadle or crank axle, thereby ensuring the adjustment movements of the former causing as little variation as possible in the distance between the saddle and the cranks. The saddle was also connected with the steering head by a strong spiral spring, so that the rider was balanced between the forward pull of this spring, and the horizontal component of his own weight on the top of the pillar raking backwards. In the "Spinaway" tricycles the balancing of the rider was effected by slinging or hanging the frame, carrying at the top the saddle or seat, and at the bottom a cranked pedal axle, upon an axle supporting the driving wheels, the driving of the latter being effected by any suitable form of balance gear, and the steering by means of a small pilot wheel placed at the extremity of an arm or projection upon the frame.†

The above was, it will be seen, an adaptation of the swing frame of the "Otto" bicycle or dicycle to a tricycle. The perfect automatic adjustment of the rider's position in the

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* For full description of this adjustable frame, see *Proceedings Inst. Mech. Engrs.*, 1885, p. 490, and 1886, pp. 149, 150, 151.

† For full description of "Kaiser" bicycle and "Spinaway" tricycle, see *Proceedings Inst. Mech. Engrs.*, 1886, pp. 151, 152, 153.

"Otto" to the gradient upon which the machine was travelling constituted the main advantage of that, and all other bicycles or dicycles wherein the two wheels were placed abreast.

In an arrangement designed by Mr Strickland, the curved portion of the backbone of a bicycle was formed telescopic, and was capable of being lengthened and shortened by means of a rack and pinion or some equivalent device.

Hurrell and Spence mounted a leading wheel of small diameter on a hinged portion of the frame, which was fitted with suitable gearing by means of which it could be raised or lowered by the rider in accordance with the gradient.

The position of the rider was also capable of being adjusted to a certain extent by using sliding seats or saddles such as the "Club," the "Matchless," &c., but the movement thus permitted was insufficient to properly effect the purpose, and any increase of the play would have rendered such an arrangement of saddle too heavy and cumbersome for use.

The great defect of all these arrangements for enabling the rider to so alter or vary his position on different gradients as to admit of his attaining a distribution of wheel load equally favourable in relation to the said gradient, as that which has been found most suitable and settled for a level, is the added complexity of the mechanism, a most undesirable feature in a cycle, and to this may be added the additional weight to the machine which must naturally be caused by the extra parts required. Where the alteration or adjustment of position had to be effected by the rider himself, and consequently each change of gradient entailed the releasing of the saddle, the moving of the latter, and the fixing or securing of it in the new position, this defect was of course added to the above. These and other reasons have probably caused the disappearance of devices for the automatic or other adjustment of the saddle by the rider when mounted.

The best method to adopt in practice is for the rider to adjust the saddle from his own experience when riding the cycle, by means of the ordinary adjustment usually provided, to such a mean position as he finds to best suit him when running on the level. He must then endeavour to maintain

his centre of gravity at the most advantageous position relatively to his wheel base by leaning backwards when descending, and by leaning forwards when ascending a hill.

Bicycles or dicycles with the wheels situated abreast, and some unicycles or monocycles alone provided perfect automatic adjustment, and that not merely for widely differing gradients, but also for slight alterations in the surface that was being passed over, which it would be totally impossible to obtain by any automatic or manual device applied to other descriptions of cycles. It was this feature which most undoubtedly rendered bicycles of the "Otto" type so easy and comfortable to ride. The defects which probably caused them to fail to come into anything like general use, and finally to become practically extinct, were the difficulty experienced in learning to ride them in a proper manner, which was greater than in the case of bicycles or dicycles with the two wheels placed in line, a very defective fore and aft or longitudinal stability, a deficiency in steering qualities, and an inability to provide a sufficiency of brake power.

MOMENTUM OF CYCLE AND RIDER.—The unit of momentum is the amount of motion in one pound weight avoirdupois moving at the rate of one unit of velocity. For example, supposing the weight of the rider to be 200 lbs., and the velocity of motion ten miles an hour, then the momentum will be equal to that of 200 units of mass moving 52,800 feet per hour, which equals 200 units of mass moving with $14\frac{2}{3}$ units of velocity, and the momentum being the product of the mass, and the velocity, viz., $14\frac{2}{3} \times 200 = 2{,}933\frac{1}{3}$ lbs. Or to state it differently. Weight of rider 200 lbs., velocity

$$10 \text{ miles an hour} = \frac{10 \times 5280}{60 \times 60} \text{ feet per second,}$$

$$\text{momentum} = \frac{200 \times 10 \times 5280}{60 \times 60} = 2933\tfrac{1}{3} \text{ in pound-feet units.}$$

POWER CONSUMED IN DRIVING.—According to G. J. and G. G. Stoney,* the power required to propel a bicycle or dicycle on a common road of average quality was found to be from $\frac{1}{7}$ to $\frac{1}{3}$ of a horse-power in accordance as the

* Paper read before the Royal Dublin Society, 1885.

rate at which it travelled varied between six and fourteen miles an hour. The experiments from which the above results were deduced were made with a machine having an elliptical lever action such as that shown in the diagrammatical view, Fig. 31, because that bicycle was found to be more easily adaptable to work a diagram indicator than those having rotary action. There can be no doubt, however, but that far more favourable results would be obtained from a modern machine of the latter class.

Before closing this chapter we will give a short abridgment of an article by H. K. Landis, E.M., upon cycle mechanics, which has lately appeared in a supplement to the *Scientific American*. Mr Landis is a gentleman who has paid very special attention to this subject, and in the article in question has given the results of some very interesting and valuable tests which he has carried out at considerable trouble and expense.

Statics.

Weight Distribution.—Taking a rider weighing 131 lbs. and a fully equipped bicycle weighing 25 lbs., or both together 156 lbs., and so placing the machine with the rider that the front wheel rested upon a platform scales, it was found that when the rider's body was in the position usually assumed for coasting the scales read 46 lbs.; when in an erect position, 47 lbs.; when in the average position, 52 lbs.; when in the middle position, 57 lbs.; and when in the scorching position, 60 lbs. The average position of a graceful rider throws one-third of the weight on the forward wheel and the remaining $66\frac{2}{3}$ per cent. on the rear wheel. In order that the tests might be amenable to comparison, they were made on a Columbia road machine. Pulling upon the handle-bars was found to decrease this weight about 3 per cent., back-pedalling increased it about 2 per cent., while forward pressure upon the pedals decreased it about 6 per cent. These figures would no doubt vary somewhat with different riders, but it may be concluded that the forward wheel will rarely carry more than one-third of the weight in ordinary riding. On a hill rising 10 feet vertical in every 100 feet horizontal this weight was found

to increase to 60 lbs. going down, and to decrease to 40 lbs. when coming up.

COMPRESSION OF TYRES.—The tests under this head were made by leaving the wheels in the above-described position supported by a rope about the seat post, and tied perpendicularly to the plane of the machine. A large wire loop was attached to both axle nuts of the forward wheel, a 12 ft. bar was placed through this loop with the short end attached to the floor and the other in the hands of the assistant, a second assistant noting with a rule held vertically when the tyre was compressed the required distance, at the same time the applied pressure being read off from the scale beam. The tyre was first inflated very hard, and the weight taken every eighth-inch compression. After this series a second was taken with slightly less air in the tyre. From these results a series of curves showing the compression of inflated cycle tyres under varying pressures was plotted. The conclusions arrived at from the result of these tests were as follows:—

That very hard blown tyres follow Professor Kick's law of proportional resistances, *i.e.*, the ratio between the pressure required and the deformation produced is constant, and the curve a straight line; but as the tyre becomes less and less inflated the ratio of pressure to compression decreases gradually as the pressure increases. The natural deduction from this is that very hard tyres have a constant degree of elasticity under all degrees of compression, while soft tyres compress easily under small pressures, and less so as the pressure increases. The latter are easier to ride upon roads where the vibrations are small, as they absorb the many vibrations that would make a hard-tyred machine tremble uncomfortably. Where, however, the amplitude of vibrations exceeds $\frac{3}{8}$ in., comparatively loose tyres should not be used. A compression of three-eighths of an inch under the weight of the rider and machine represents probably the general safe and also comfortable degree of inflation. Cyclometer readings depend upon the compression of the tyres. A hard tyre without rider traverses 7 ft. 4 in., with rider, 7 ft. $1\frac{1}{2}$ in., while a tyre where 132 lbs. compresses it $\frac{3}{4}$ in. will traverse but 7 ft., a loss of 5 per cent. for the cyclometer.

CENTRE OF GRAVITY.—Taking the horizontal distance between the axles of the fore and rear wheels as a balance arm, having the weight on the fore wheel tyre on one end and that on the rear wheel tyre on the other. The wheel being in equilibrium, this balance arm would be supported at its centre of gravity, and therefore the weight of the forward wheel times its end of the balance arm, which calling x, will equal the weight of the rear wheel times its horizontal distance from the centre of gravity, $45.5 - x$ in., or $52 \times x = 104\ (45.5 - x)$, from which $x = 30.3$ in. from the fore wheel axle. A vertical through this point will be the line in which the centre of gravity will lie. A change in the elevation of the rear wheel will create another locus of the centre of gravity, in the same manner with the platform scales as in the first test. Observations made at elevations of 15° and 20° inclinations of both wheels, including the horizontal, gave five loci which should have gone through the same point. The centre of gravity of the machine and rider, whose body inclined 20° from the vertical, was at the forward point of the saddle. The centre of gravity was highest in the coasting position. Were a great obstruction encountered, with the rider's feet in position at the top of the forks, his body would be prevented from leaving the machine, the whole weight being raised through the distance of 1 ft. and taking a header; if, however, the rider had his feet on the pedals, he would be simply projected over the handle-bars, the machine remaining behind, the striking energy imparted to the mass being that due to the motion —of 25 lbs. instead of the total of 156—and the cycle would probably remain comparatively unhurt instead of being wrecked as in the former case.

STRENGTH OF PARTS.—The factor of safety in a modern (1896) cycle is estimated at 1.5, whilst in most other machines it is usually 4 This small margin (not much more than one-fourth of that in other machinery) of safety in the cycle, rendered necessary by the demand for light machines, should be compensated for by the use of none but the best materials. After annealing, which is the condition of all brazed parts, the strength of low carbon steel (0.20 per cent. of carbon) falls to 50,000 lbs. from the original 70,000 lbs. required to pull apart a bar 1 in.

square; high carbon steel (0.50 per cent. of carbon) falls from 90,000 lbs. to 65,000 lbs.; and nickel steel (5 per cent. of nickel) remains at about its original 100,000 lbs. It is evident, therefore, that the latter material is the one which should be employed. Handle-bars should be made of tempered nickel steel requiring a pull of over 450 lbs. to bend it. A ton and a half gradually applied to the seat post will be required to crush a good steel frame, but 700 lbs. only, applied horizontally to the front wheel shaft, the rear one being fixed, will cause the lower tube to buckle on its upper side by reason of vertical forces. The front quadrangle of the frame is a poor construction, owing its strength to the stiffness of the jointing alone, and should obviously be modified in accordance with the methods employed in bridge construction. The factor of safety of the chain is usually 7. At a speed of 10 miles an hour the pressure on the pedal would be 47 lbs., and the tension on the chain 106 lbs. This was determined thus:—Pressure on pedal times length of crank centre to centre will equal tension on chain times radius of large sprocket wheel, or power times power arm equals weight times weight arm, viz., $47 \times 6.75 = x \times 3$, or $x = 105.75$.

A tyre of ordinary construction would squash flat at 450 lbs., and would burst at 200 lbs. pressure per square inch. A wheel would buckle at from 600 to 800 lbs. pressure. A carefully brazed and pinned joint would stand the tube breaking before being pulled out. The difficulty is to know for certain when it has been properly brazed before testing. Two million successive bumps would be required to break a first grade wheel, but a poor wheel would give way under one-third that number. Low carbon steel tube subjected to successive stresses beneath, but near, its elastic limit, would break at the end of 300,000 revolutions; high carbon steel would withstand 400,000 stresses; nickel steel, 1,500,000.

Dynamics.

Traction.—According to D. K. Clark's formula for locomotive traction on iron rails, a drawbar pull of 1 lb. is necessary for a weight equal to that of a bicycle. Robert Wilcox has deduced the equivalent for bicycle traction in

ounces as $t = \frac{v^2}{100} + 7.75$ adding 0.5 t for speeds over 5 miles an hour, which at 10 miles an hour would give a traction of 13.12 ozs. Rudolph Hering estimates the traction on a good macadam road at eight times that on iron rails, which would give a tractive force necessary of 6.56 lbs. Actual tests with a spring balance and a horse drawing the cycle and rider along at the required speed, without the said rider exerting any tractive force, gave a drawbar pull of 4 lbs. on good macadam roads, and 6 lbs. on mud roads: these tests were repeated to confirmation. It was also shown that increase of speed appreciably increased the power required, and that ordinary hills required 12 lbs. to 16 lbs. to climb.

PRESSURE ON PEDAL.—This is derived directly from traction. At 10 miles an hour the foot should press upon the pedal uniformly throughout the half revolution with a pressure p, the total pressure by both feet per revolution being $2p$; whilst, however, this pressure, which is only entirely effective at half stroke, is moving through the diameter of the crank circle — 1.125 ft. — by a round-about way, the resistance, which is constant, acts through the semi-circumference, and is therefore $\frac{p}{1.57}$ lbs., or $\frac{2p \times 1.125}{1.57} = 1.43p$ foot-pounds per revolution of the crank. To one revolution of the crank the wheel tested travelled 10.86 ft. Ten miles an hour is 14.7 ft. per second, the work done on the pedal would therefore be $1.24p$ per second, equalling 4 lbs. traction acting through 1.47 ft., or $4 \times 14.7 = 1.24p$, from which $p = 47$ lbs. on smooth macadam, and for 6 lbs. traction on mud roads, 71 lbs.

WORK DONE.—Four pounds acting through 14.7 ft. per second would require $\frac{4 \times 14.7 \times 60}{33{,}000} = 0.106$ horse-power per minute, or 0.636 horse-power per mile.

ENERGY OF MOTION.—A number of experiments were made to determine the static pressure exerted upon the front wheel when stopped suddenly, a spring balance with sliding recorder being attached to the long end of a 19 to 1

lever, and the other fastened to the bicycle as it passed. At a velocity of 4.47 miles per hour the pull recorded was 11 lbs., or 200 lbs. on the cycle, the weight stopped being that of the machine only, the rider leaving the saddle at once on stopping. When the rider clung to the saddle the energy of motion was higher. For a velocity of 4.5 miles per hour the average pressure was about 250 lbs., which would be sufficient to compress the tyre up to the rim: 8 miles per hour would produce sufficient pressure to endanger the frame at a point on the lower tube near the steering head; 12 miles per hour would engender enough to crush the wheel.

VIBRATION.—The vibrations occurring near the centre of gravity, from loose stones, ruts, &c., on the road, were recorded in seismograph curves by a specially constructed instrument wherein the pencil style was held against the paper by the tension of a rubber band, and was free to move in all directions against approximately equal resistances. The impact curve recorded showed a first sharp dip, which indicated a sharp rising of the rear wheel, whilst the tyre was compressing; a long top curve gave the measure of the shock, and a deflection showed the settling back of the rear wheel. The passage of the wheel over an inch obstruction showed the resultant vibration to be in the direction of a line drawn through the pommel of the saddle and a point about 4 ft. in front of the point of contact of the front wheel with the ground. Upon the rear wheel passing over the same obstruction the vibration was in a line with the saddle pommel and a point slightly above the rear wheel shaft. These two lines of vibration would make a little more than a right angle with each other, and would give the rider the maximum effect in an all-round shaking up. On a smooth road there was more rear wheel vibration, indicating the desirability of an easy saddle; on a rough macadam road, however, the line of vibration passed through the front wheel shaft, and the bulk of the vibration was on that wheel.

ECONOMIC CONSIDERATIONS.—The traction on asphalt was found to be one-fourth, and on brick one-third that on good macadam streets.

CHAPTER VII.

Component Parts of Cycles.

THE main parts that go to make up a cycle are five in number, viz.—First, the framework; second, the wheels; third, the steering; fourth, the driving gear; and fifth, the saddle or seat.

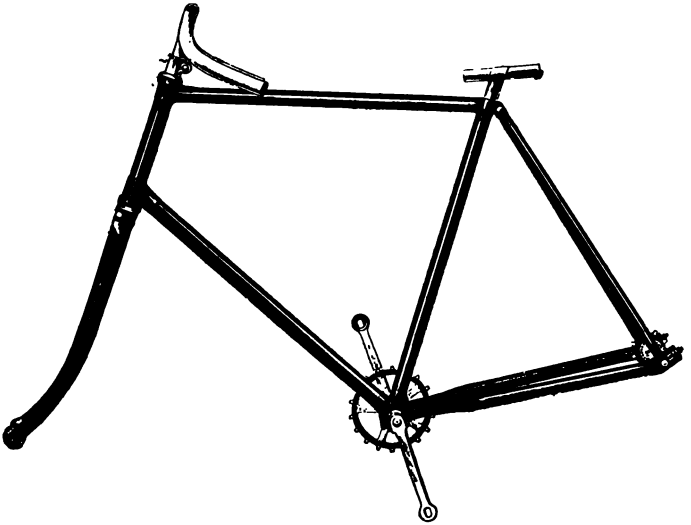

Fig. 35.—Standard Pattern Bicycle Frame.

In addition to these, however, there is the brake mechanism, which although not absolutely indispensable, is nevertheless a most important part; and there are besides a number of accessories, the most necessary of which are lamps, bells or alarms, and gear cases.

THE FRAMEWORK.—This subject will also be further dealt with in the next chapter. As has been mentioned, the frames of cycles are at the present time almost universally made of weldless steel tube, and Fig. 35 shows a standard pattern for a bicycle, as made by Perry & Co. Limited. A new material, however, has lately been found in the bamboo, and frames made therefrom are now constructed and applied

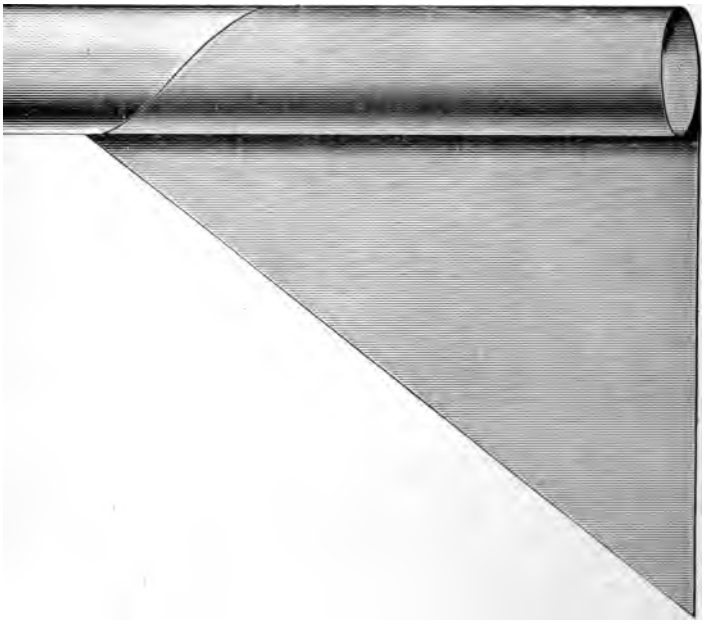

FIG. 36.—Premier Co. Helical Tube.

to machines by the Bamboo Cycle Company Limited. Various other materials, moreover, have been proposed and used for cycle frames, such as compressed paper or wood pulp, laminated wood, and aluminium, which latter metal possesses many advantages over steel for the purpose, and which most probably will be in a few years extensively, if not exclusively, employed.

When weldless mild steel tubes are used, they vary in thickness according to their diameter, usually running, however, from .065 to .095 inch. The present practice is to employ tubes of a large diameter and thin gauge. According to H. K. Landis, nickel steel (5 per cent. of nickel) is about twice as strong as low carbon steel of 0.20 per cent. of carbon.

The metal tubes mostly used in this country consist either of solid drawn mild steel tubes, or of special tubes such as that known as helical tube, which has been patented and is made by the Premier Cycle Company Limited (Hillman, Herbert, & Cooper Limited), and which is illustrated in Fig. 36. This tube is formed by wrapping, twisting, or rolling helically a thin sheet of metal, varying from .008 inch to .017 inch, and firmly brazing it together. The mode of manufacture adopted for making these tubes is shortly as follows:—First, strips of the requisite length are cut off by means of a guillotine shears from the long rolls as they come in from the makers, the cuts being made diagonally so as to end square when the tube is finished. The next operation is to roll the strips round a mandrel, which operation is effected in a special machine, consisting of a set of three rolls mounted horizontally, and one of which is removable to admit of the mandrel being placed in position. Upon rotating these rolls the mandrel will be also caused to revolve, as the strip and mandrel are in contact with the said rolls, and consequently the said strip will be drawn in and so wrapped or wound round the mandrel as to form a tube. This winding is performed at such an angle that whilst there will be a double thickness of sheet at all parts, at those points where the overlap occurs there will be a treble or threefold thickness of the said sheet. A clamp is then placed upon one end of the coiled strip or tube to prevent it from unwinding by reason of its elasticity, and it is removed from the rolls, the mandrel upon which it was wound is withdrawn, a stout collar driven upon the extremity of the tube, and a plug forced into its bore so as to hold the strip firmly in its coiled state until the latter are solidly united by brazing. This latter operation is performed by running hard solder into the tube, and likewise so applying the said solder to the exterior of the said tube

that a portion will adhere to those parts where the coils or convolutions overlap. This solder is then melted and run into the joints between the strips in a gas furnace, the tube being turned and shaken to facilitate and expedite the passage of the solder into the said joints. After having been permitted to cool down in powdered lime, the collar may be knocked off, and the ends of the tube cut off square to exact length. The perfection or otherwise of the brazing operation can be ascertained by hanging up the tubes and striking them, those that fail to ring clearly being condemned as unfit for use.

These helical tubes have proved themselves when subjected to very severe tests to be considerably stronger than the plain solid drawn steel tube. The chief reason for this is, that whilst the latter must of necessity be made from very mild steel, the former on the contrary can be constructed of high carbon steel just below the air hardening point. Besides this, however, the helical tube can be so constructed as to offer perfect uniformity of gauge, which is not the case with solid drawn steel tubes wherein the walls are liable to vary to a certain extent in thickness, and thereby to necessitate the enlargement of the margin of safety, and the employment of tubes of a weight which, but for this probable fault, would not be required.

The junction obtained between the convolutions by the brazing process is so perfect that upon forcing open the strip, as shown in the illustration, a complete film of brass would be found between the plates. This film of brass is claimed, besides firmly uniting the strips so as to form a practically homogeneous tube, to add appreciably to the toughness of the finished article.

Exhaustive tests conducted by David Kirkaldy and J. M. Reilly, have given very favourable results in favour of the helical tube as compared with the ordinary weldless steel tube.

During the tests carried out by the first-named gentleman, six pieces were tested. Taking, however, the results obtained in the tensile and bending tests with one sample only by way of example, we find that in the first, whereas it took 13,005 lbs. to arrive at the ultimate pulling stress of a piece of helical tube of .97 inch outside diameter and weighing

.371 lb. per foot-run, or 121,542 lbs. per square inch, it only required 8,403 lbs. to reach that of a piece of solid drawn tube of 1 inch in diameter and of a like weight per foot-run, or 79,274 lbs. per square inch. The extension was 1.5 per cent. in the former, and 18.7 per cent. in the latter in 10-inch lengths; and the contraction of area was respectively 3.7 per cent. and 37.7 per cent. As regards the bending tests the deflection of a piece of helical tube of .97 inch in diameter, and weighing .346 lb. per foot-run, supported at points situated 15 inches apart, was for a centrally superimposed weight of 100 lbs., .03 inch; for 200 lbs., .058 inch; for 350 lbs., .100 inch; for 500 lbs., .150 inch; for 900 lbs., .44 inch; at 942 lbs., the tube gave way, buckling and cracking. The elastic stress was 750 lbs. With a solid drawn tube on the other hand weighing .339 lb. per foot-run, tested under precisely parallel conditions, the deflection was as follows:—For 100 lbs., .025 inch; for 200 lbs., .040 inch; for 350 lbs., .33 inch; at 360 lbs. the tube gave way. The elastic stress in this case was only 280 lbs.

With respect to the tests made by J. M. Reilly, a frame built of helical tube weighing 5 lbs. $5\frac{3}{4}$ ozs., when subjected to a condensed lateral strain, as in case of a collision, was found to have an ultimate strength of 448 lbs., whilst a frame constructed of weldless tube weighing 5 lbs. $13\frac{3}{4}$ ozs. only gave an ultimate strength of 264 lbs. Under a transverse test, the tube being supported at the ends 12 inches apart, and loaded in the middle, a helical tube of 1 inch external diameter, .026 inch in thickness, and weighing 4.05 ozs. per foot-run, developed an ultimate strength of 848 lbs.; a weldless tube of the same external diameter, .027 inch in thickness, and weighing 4.06 ozs. per foot-run, only giving an ultimate strength of 387 lbs. A compression test with the load applied parallel to the axis of the tube gave for a helical tube of 1.01 inch in diameter, .027 inch in thickness, and weighing 4.19 ozs. per foot-run, a total load of 5,540 lbs., or an ultimate strength per square inch of 131,900 lbs.; and for a weldless tube of 1 inch in diameter, .027 inch in thickness, and weighing 4.03 ozs. per foot-run, a total load of 3,760 lbs., and an ultimate strength per square inch of 91,710 lbs.

It will be thus seen that the results of these tests indicate

that the helical tubes are, for such duties as are likely to be met with in cycle frames, more than twice as strong as the ordinary weldless tubes. These helical tubes are at present constructed in sizes varying from $\frac{3}{8}$ inch up to $1\frac{3}{8}$ inch.

The present practice tends to the use of tubes of large diameter for the framework, but although advantageous if carried to a reasonable extent, when too large they must of necessity be of too thin a gauge in order not to become of excessive weight, so much so indeed, that in some cases where tubes of abnormally large diameters are used, they have to be of so thin a gauge, and consequently so easily dented or bulged as to be absolutely dangerous. Another fashion getting to be much in vogue just now is the employment of oval and D-shaped tubing, which is objectionable, as a considerable loss of strength is as a rule entailed by the use of tubes of these transverse sections. The front fork, however, may advantageously be drawn and tapered into an oval section, to enable it to better withstand the torsional strains to which it will be subjected by the rider's manipulations of the steering or handlebar.

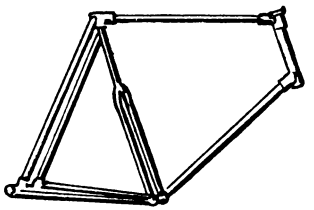

FIG. 37.—Fowler Truss Frame.

The plan also now prevalent of making the frames of cycles of single members is not apparently the most advantageous possible. The joints require to be of very great strength, and even then the rigidity of the framework is not nearly so great as it would be were double tubes, of smaller diameter, suitably braced together, employed, either altogether or for certain parts of the said framework. The latter, moreover, even under ordinary conditions need not exceed the former in weight, or at any rate only do so to a very trifling extent, and with certain modifications might be made even somewhat lighter.

Whilst manufacturers in this country seem to cling with extraordinary tenacity, probably by reason of its cheapness, to the framework composed of single straight members, consisting frequently as before mentioned of tubes of large

diameter, and dangerously thin gauge, one American company at least has made a decided step in advance. Fig. 37 illustrates a framework for cycles built by the Fowler Cycle Manufacturing Company, U.S.A., on the truss principle, by which the frame is rendered far more rigid, and is greatly strengthened.

Numbers of patents have been taken out from time to time for framework composed of compound members, and for other means for increasing the strength thereof. The following brief abridgments of a selection from those of most recent date will be of interest :—

C. T. Crowden, No. 22,721 of 1895, uses an outer tube

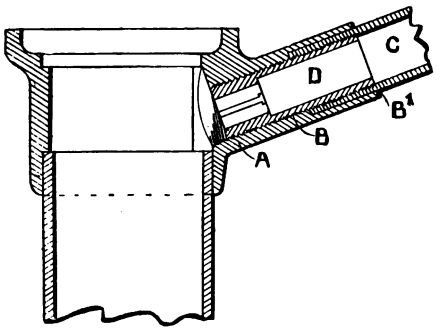

FIG. 38.—Method of forming Joints in Frames without Brazing.

or socket with double spiral grooves, and swells the inner tube by hydraulic pressure, so as to force it into the said grooves. This system of jointing is said to have been in use in the United States for some time past.

F. Bowden, No. 23,703 of 1894, describes a framework for cycles, wherein the steering socket is connected with the diagonal or rear part by a straight member and two crossed members, the former being situated either above or below the latter, and braced thereto by means of a strut or tie if found desirable. This frame is chiefly intended, and would be most suitable, for a lady's machine. A removable top stay is, however, also mentioned, which can be fitted in position when the machine is required for use by a gentleman.

A. Trouvé, No. 23,105 of 1894, provides a frame for cycles so constructed that the junctions at the ends of the top horizontal member will fall upon vertical tangential lines.

C. F. Pichard, No. 20,623 of 1894, forms a framework for cycles wherein the joints or junctions are made without brazing. The method of effecting the junction of the various members of the frame therein described consists essentially, as shown in Fig. 38, of the use of sockets and internal taper plugs or ferrules. As will be seen from the illustration, the socket A is bored with conical openings B, B^1, into which the end of the tube C is fitted and expanded by a screwed taper plug or ferrule D. In some cases the inner and outer part of the plug or ferrule is left plain or unthreaded. These joints are claimed to be suitable for application to the backbone, steering-device, guide-fork, saddle-support, crank mechanism, and handle-bars.

G. Barker, No. 8,387 of 1893, constructs frames for cycles with three, four, or more parallel members extending from the steering head, and strengthened by means of struts and ties.

A. C. Hide, No. 17,624 of 1893, provides for strengthening the joints by using joint pieces made out of sheet metal, their abutting edges being so shaped or formed by dovetailing as to interlock with each other, and hold them fast for brazing.

W. Grayson and L. J. Crecelius, No. 12,112 of 1893, construct hollow frames for cycles, which are to be formed in one entire piece by casting the same, preferably in polished metal moulds, from aluminium bronze or other aluminium alloy.

W. B. Smith, No. 10,220 of 1893, describes a method of strengthening the framework of cycles. The tubes, according to his invention, are thickened at the top to resist compression, and are sometimes formed elliptical in transverse section, or bars I-shaped in transverse section, are used, the bend being thickened if necessary. In the case of the latter, the lower and upper portions of the bars may be bent over, so that their edges nearly or quite meet. Tubes formed of plate, and with an internal web, are also described. These latter are to be united by an internal plug, or if joined at an angle one of them may be cut away so as to leave a portion of the web projecting, which latter is then passed through the other tube, and riveted over.

A. W. Kirch-King, No. 2,117 of 1893, claims to have devised a method of joining or jointing together the frames of cycles, whereby better results can be obtained than is possible with the ordinary brazing operation. He unites or joins together the tubes of the framework to other metal parts by means of bolts and screws, and conical or other hollow expanding wedges. To make a butt joint the extremities of the tubes are inserted into a sleeve, and are expanded by a bolt, conical wedges, and a double conical split bush.

C. H. Guest and L. Barrow, No. 4,995 of 1891, build the framework for cycles by fixing together the solid or tubular members, and the necessary fittings, by means of bolts, rivets, or pins, and then completing the joints by galvanising, either by immersing the frame in a zinc bath, or in separate zinc and tin baths.

A. Sharp, No. 13,043 of 1888, describes a frame for cycles, formed in two parts, each composed of five bars or tubes, which together with the wheel axle are arranged as the six edges or sides of an irregular tetrahedron. The two parts above mentioned are hinged together to form the steering joint.

G. Singer, No. 9,966 of 1888, provides a framework for cycles, wherein the steering wheel is mounted in an ordinary fork, the steering stem of which passes through the usual socket. The driving wheel is mounted in a triangular frame of segmental tube, and pairs of tubes connected to brackets. One of these brackets has a curved extension with a socket for the seat pillar, and is also connected by a horizontal rod with the said socket. The segmental tube above referred to is connected with the seat socket by the main tube.

Frames for cycles have also been designed which are composed of double sheets of metal brazed at suitable distances apart, or of sheets of metal flanged at its edges, and likewise, as previously mentioned, of papier-mâché, compressed paper, thin sheets of wood, &c. &c.

In a patent that has been already referred to, taken out in 1890, No. 5,767, by G. L. Morris, W. T. Wilson, and V. H. Strickland, is described a box-like frame made of sheet steel, or other metal plate, the edges of the said plates forming the frame being brazed together, or secured by strips of metal.

In the specification of the preceding patent, like box-shaped frames to the above, formed of papier-mâché, wood, cardboard, &c., are also described.

As has been also already mentioned, bamboos are now employed to a certain extent in the framework for cycles. A serious objection to the use of this material is the great difficulty that must evidently be experienced in the obtainment of strong and lasting joints between the bamboo canes or tubes, and the metal sockets.

Several methods have been devised for making the joints in bamboo frames, amongst the latest being that of Horace Walter Dover, for which a patent (No. 8,906) was granted in 1895. The main features of this plan are the means adopted in order to prevent the weakening of the bamboo tubes, at their points of junction with the metal sockets, through the removal of the outer skin, and by the further

FIG. 39.—Dover's Method of forming Joints in Bamboo Frames.

reduction of diameter consequent upon fitting. For this purpose the ends of the bamboo cane are brought to a truly cylindrical form by moulding around the said ends a layer of plastic fibre, cement, or similar substance, as shown in Fig. 39, which will set hard, and be caused to firmly adhere to the skin of the bamboo. This substance is applied by moulding under pressure in moulds, the screw thread being at the same time produced upon the moulded surface by providing the said moulds with suitable internal threads.

In another arrangement patented by Grant M'Anney, in the same year, No. 8,832, the ends of the bamboo tubes are inserted, as shown in Fig. 40, in sockets B, B^1, forming parts of the metal sockets joining together the separate members of the frame. C is a pin inserted through the socket B, just beyond the end of the bamboo tube. D is a wire (shown in dotted lines), a loop or hook at one end of which

is passed over the pin C, and which wire is then carried centrally down the said socket B and the bamboo tube to the other socket B^1, in which is fitted a nut adapted to screw on the end of the wire D. It will be seen that by rotating this nut in one direction in its bearing in the socket B^1, the two sockets will be drawn together, so as to compress the bamboo tube between them. The mouths of the sockets are sometimes formed smaller than the interior parts, and the bamboo tube is steamed, and thereby softened, before insertion, so that it can be forced through the said narrow mouths, and will afterwards expand so as to fill the sockets. Sometimes the sockets are in addition split, and tightened in any known manner upon the bamboo tubes.

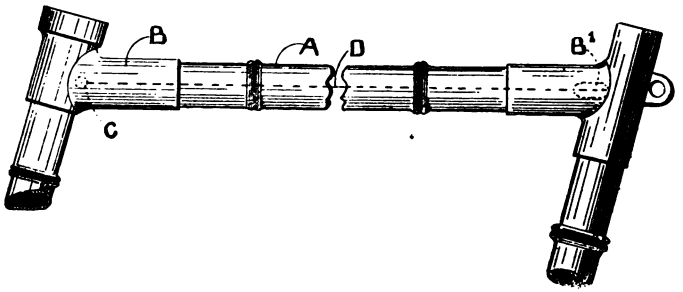

FIG. 40.—M'Anney's Method of forming Joints in Bamboo Frames.

In yet another manner of forming the joints which was patented by M. Harrington and A. Anthony, in 1894, No. 8,274, the ends of the bamboo tubes are plugged and screwed, preferably along with glue or cement, into screw-threaded holes formed in the junction pieces or sockets. The ends of the junction sockets are ferruled or bound with wire, and it is also recommended to bind the tubes here and there with wire to obviate the splitting thereof, to which they are otherwise presumably liable. If the sockets or junction pieces are made of a metal to which the bamboo canes cannot be connected in the above-described manner, the sockets of the said junction pieces are split, and clamped on the former by means of screws, ferrules, or otherwise.

Several convertible cycle frames have been already briefly described. A cycle frame has also been designed by Marriott & Cooper, which is very readily convertible from a gentleman's into a lady's pattern or the reverse. To effect the alteration all that is required is to adjust a movable top stay from the gentleman's position to that suitable for ladies' use, or *vice versâ*. This type of frame can be built as light as an ordinary pattern gentleman's frame, as the top stay instead of being entirely removed, as is usually done in convertible machines when adapting them for ladies' use, is retained in another position, and serves to stiffen and strengthen the frame.

Numerous spring frame cycles have been devised from time to time, some of which present some very desirable features. The Humber spring frame for a safety bicycle or dicycle, which is very suitable for use by heavy riders on rough or uneven roads, as it obviates or greatly reduces the injurious jolts or shocks which are imparted to the rider when passing over inequalities of surface with a cycle having a rigid frame. The construction of this framework is very simple, consisting merely in pivoting the fork carrying the rear wheel to the bottom bracket, and connecting an extension or stem of this fork to a downwardly extending stay, starting from the top of the steering-head, through a spiral spring. The front wheel is mounted between the short arms of two levers pivoted to the extremities of the fork, the other or long arms of which levers are connected to the fork arms by similar spiral springs. The strength of these springs must of course be adapted to the weight of the rider. This spring arrangement is likewise applied to frames designed for ladies' machines.

The following are some of the many patented types of spring frames for cycles:—

J. Anderson, No. 9,379 of 1891, describes spring frames for cycles constructed of steel tubing charged with compressed air, and fitted with cylinders and pistons so as to neutralise vibration. In an example given of a bicycle frame built on this principle, the tubular members are fitted with cylinders and pistons, and charged with compressed air, the latter operation being effected by means of an air pump or injector, which is so arranged that it will be worked

or actuated by the movements of the saddle, and which is connected up by a flexible tube. The compressed air within the hollow framework is also intended to be employed for sounding alarm signals.

The idea of constructing a pneumatic spring frame in the above-described manner, whilst somewhat ingenious, and perhaps novel, would seem to offer too many difficulties in its practical application to be of any service for general use.

J. E. Hull, No. 5,682 of 1890. This inventor describes a spring frame for a safety bicycle, wherein the backbone is formed of a single double or forked bowed spring to which is connected the seat pillar. The said seat pillar may be extended to form the crank axle bracket or a separate flexible piece can be employed for that purpose. A second inverted bow spring is arranged beneath the backbone, or this may be replaced by suitable stays, which are then connected by a sliding joint preferably controlled by a spring.

Henry Green, No. 18,235 of 1889, provides for the utilisation of a spiral spring between the base-jaw and handle-bar bracket of a cycle fork in conjunction with a neck pillar, and jointed suspension plate or plates connected crossways.

In addition to these mention must be made of that of Linley & Biggs, which, under the name of the "Whippet" Spring Cycle Frame, some ten years ago achieved a very considerable amount of popularity, and would doubtless have become a great success had not the advent of the pneumatic tyre rendered the use of spring frames practically unnecessary, except under very special circumstances. The "Whippet" frame consisted of a somewhat ingenious arrangement of toggle-levers and springs.

Under this category must also be placed all such devices as those in which attempts to negative the molecular vibrations are made by cushioning the joints with air. Besides pneumatic frames, such as have been above described, others have been designed from time to time, wherein pneumatic hubs and pneumatic boxes between the spindles and fork ends were provided. None of these devices, however, are able to absorb the shock of charging an impediment in the manner done by a pneumatic tyre, by which not only are the molecular vibrations taken up, but likewise the larger

movement of the whole mass, which latter is an impossibility so far as spring or pneumatic frames are concerned.

WHEELS.

The wheels of cycles consist of four principal parts—the hubs, rims or felloes, spokes, and tyres.

HUBS.—Firstly then, dealing with the hub, so as to take the components of the wheel in the above order.

The most important part of the hub is the bearing, now without exception constructed with anti-friction balls or spheres inserted between the moving parts or surfaces.

The use of ball bearings in cycles is by no means of recent origin, having been suggested, as has been already mentioned, by E. A. Cowper in 1868, and in the next year (1869) several arrangements of this type having been devised. It was not, however, until some years after this date that they came into use to any appreciable extent, the first ball bearing to attract any considerable attention being that known as the "Æolus," in 1879. The date of J. H. Hughes' patent is 1877, No. 3,531, and of that of W. Bown and J. H. Hughes, 1880, No. 1,227.

The introduction or rather the popularisation of ball bearings formed an important event in the history of the cycle; indeed, it may without exaggeration be said that the general introduction of this class of bearing restored to life what at that time bid fair to become a dying industry. This result was no doubt due very largely to the novelty of the matter, as it is more than doubtful if some of the types of ball bearings first used facilitated propulsion to any appreciable extent by the reduction of friction, as compared with well-fitted long parallel bearings. Whilst, on the other hand, the concentration of the load upon the journals which takes place with ball bearings very frequently resulted in broken axles, which latter fault indeed is one to which even the most modern types are liable, unless great precautions in the making of the axle be taken.

Primarily the balls or spheres were separated from each other, in the box or casing wherein they were intended to work, by surrounding them with a pierced ring or tube, through the

perforations in which the said balls or spheres were arranged to project and work against the inner surface of the box. This pierced ring, which was found to be most objectionable in practice, was after a time dispensed with, but still some device was used for keeping the balls or spheres at equi-distances apart—such, for instance, as side discs having suitably spaced shallow radial grooves to receive the balls or spheres. These grooved discs were usually connected together so as to form a species of cradle or frame, which would surround without touching the axle or bush, or the interior of the box, wherein the balls or spheres work, and the said discs were, moreover, arranged at such a distance from each other as to permit free motion of the balls or spheres, and yet to retain them evenly or equi-distantly separated from each other. In another arrangement the balls or spheres were loosely mounted between recessed discs in which the balls worked as if on points. Finally, it was found that the best results were attainable when the balls or spheres were allowed to follow each other freely upon a circular path, without any attempt being made to maintain them at set distances apart.

In the specification accompanying an application for provisional protection made by J. Harrington and H. Brent in 1879, No. 869, is described a bearing, wherein the interior of the box or casing was to be lined with a hardened steel bush formed with a circular groove or grooves on its inner face, around which the balls or spheres were to work. Upon the axle was to be fitted hardened steel collars or bushes meeting at the point or points where the circle or circles of balls or spheres revolve, at which point or points a groove or grooves should be formed in such bushes to accommodate the balls or spheres, and retain them in their correct position.

In another provisional application made in the same year, No. 4,660, by N. K. Husberg, this inventor says that to diminish side friction in the bearings of axles, and also to prevent the wobbling of the wheels, especially when the bearings become somewhat worn, he inserts small balls on one or both sides of each bearing, between it and the hub, axle, crank, steel collar, or other adjoining parts, forming a ring, or a portion of a ring, round the axle, close to or at

some distance from it. These anti-side friction balls were to be maintained in position by means of flanges, or by working in grooves formed concentric with the axle, or in the bearing or adjoining parts, or both.

In a patent also taken out in the same year (1879) by G. Singer and W. Granger, means for adjustment of the parts is provided. A split case is arranged to contain the bearing, one end of which case is internally screw-threaded to receive a correspondingly screwed washer. The axle is provided with two flanges, against the outer sides of which a series of balls or suitably shaped rollers take their bearing, the opposite peripheries of which are pressed by the aforesaid washer, which screws into the end of the split case. By this means the position of the balls can be adjusted with the greatest nicety, and side shake is claimed to be practically prevented. Either short rollers or balls were inserted in the centre between the flanges, which latter rollers or balls were only designed to take the weight. At each end of the bearing was also provided a loose perforated disc, by which the end balls were retained and adjusted in position between the perforated disc and the second flange upon the axle.

The use of long bearings, so successful in other machines, in cycles is open to very serious objections for the following, amongst other reasons :—They must be of at least two diameters, and should preferably be of three diameters, in length ; and, moreover, they should be so arranged as to be swivelling or adjustable to avoid locking, and they have consequently the fault of taking up a considerable amount of room, and also of requiring both frequent and abundant oiling.

The advantages derivable from the use of ball bearings in cycles has been very clearly stated by F. G. M. Stoney* as follows :—" Friction itself, he considered, was the smallest element of resistance in a cycle. The machine was constructed with a very delicate frame, and therefore could not have bearings of any length—no matter how beautifully made—because locking would take place ; and it was locking in bearings that caused the resistance, not their friction.

* *Proceedings Institution of Mechanical Engineers*, 1886, page 177-189.

Cone bearings had been tried, and had been found to be very bad, because the better they were adjusted, the more did they aggravate the tendency to locking. The advantages attending ball bearings were not that they had a beautiful rolling motion, because they had not. In most cases the action was that of grinding, and in many of the bearings which he had seen it was a matter of mathematical impossibility that the balls should roll freely; they did not roll. The real advantage in a ball bearing was that the bearing was narrowed down from a journal to a mere line; and, therefore, however, the frame might twist, it could not lock the bearing. Not only was the bearing reduced to a single line, but even in that line no more than a single ball* was bearing at any one time. Even if any of the others happen to be bearing a very trifling amount, yet it was the uppermost ball which really carried the load for the time being; and it was because it was a ball, and not a fine-edged disc, that the bearing point was kept renewed, and there was an entire absence of locking. The diagram sketched in Fig. 41 illustrated his own view that a ball bearing should be treated exactly like a conical bearing or a pair of mitre wheels or bevel wheels. This was a point which he believed was generally neglected; for all the ball bearings which he had examined had got a curve at each side of the ball, and it was that curve which appeared to him objectionable, because he did not believe in the possibility of getting any

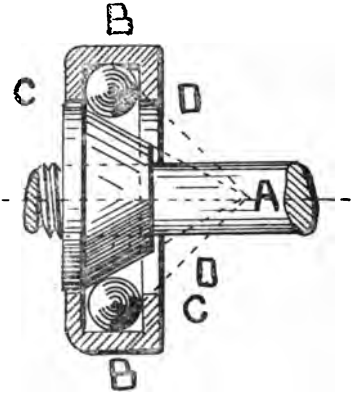

FIG. 41.—Diagram showing Construction of Typical Ball-Bearing.

* In the author's opinion, which is confirmed by that of at least one engineer, who has had considerable practical experience in ball bearings, the load is carried nearly equally upon the balls forming about a third of the circle.

curve in exactly the right place for keeping the ball rolling in the same way that it would do in a proper conical bearing. For simplicity, therefore, he considered it would be preferable that the upper portion of the bearing should be shaped at right angles, as shown at B and D in Fig. 41, because that was the simplest possible form. Then a line drawn through the two points of contact at B and D would be at an inclination of 45° to the axis of the bearing, and its intersection with the axis at A would be the apex for the cone, from which a tangent drawn to touch the opposite side of the ball at C would itself give the proper cone for the surface of the conical journal. As the circular paths described by the ball's three points of contact were not of equal diameter, the rolling motion of the ball would be of a differential nature. It would be seen that this simple construction of ball-bearing had the advantage that the three bearing surfaces could all be made perfectly true with the utmost ease."

Considering the grinding action which must of necessity take place in the ball-bearings as universally constructed, the longevity of the balls or spheres has frequently been a matter of considerable surprise, and one rather difficult to account for. The wear, indeed, is almost imperceptible, as has been proved by the result of experiments made by Prof. Vernon Boys, who obtained the following interesting and remarkable results:*—"When the balls were taken out after every two hundred miles, and examined and weighed, he had found that their wear was at the rate of $\frac{1}{250}$th of a grain per ball for every thousand miles. On afterwards running the machine a thousand miles without taking the balls out at all, he found to his surprise that the wear was almost identically the same as in any one of the previous runs of only two hundred miles. He therefore, concluded that the amount of wear was due, not to the actual proper rubbing and rolling of the balls round the bearing, but to such little dirt as could not be prevented from getting in whenever the cap was taken off, and screwed on again. The extraordinary result, however, came out, that, while in a thousand miles each ball turned about 1,400,000 times on

* *Proceedings Inst. Mech. Engrs.*, 1885, p. 510.

its own centre, its loss of weight in turning that number of times amounted to less than $\frac{1}{1000}$th of a grain: which might be taken as another way of saying that the balls did not wear at all.* When the design of ball bearings was spoken of as bad, because the surface of the balls where they touched one another were going opposite ways, and instead of rolling were tearing themselves to pieces, he thought in view of the facts he had mentioned, it was decried very rashly."

In practice the wear takes place almost exclusively on the cones or ball races, which after a certain amount of work

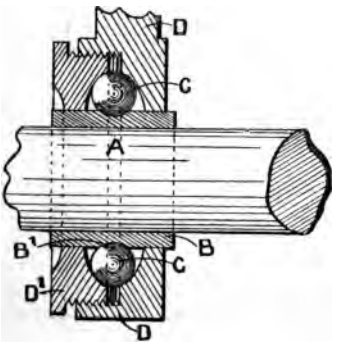

FIG. 42. Æolus Ball Bearings.

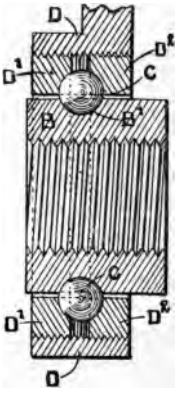

FIG. 43.

will invariably be seen to be more or less grooved by the balls. For this reason it is found desirable in practice to form the cones with slightly curved or concave surfaces, so as to thereby diminish the deviation that results from this wear.

A series of experiments carried out by the late George

* The twelve balls in a bearing lost together only $\frac{1}{20\cdot8}$ grain in weight in running a thousand miles, or only $\frac{1}{250}$ grain per ball, equal to an actual surface wear of only $\frac{1}{158000}$ inch.—*Proceedings Inst. Mech. Engrs.*, 1885, p. 500.

F. Simonds, of Fitchburg, Mass., U.S.A., the inventor of the round forging machine and of a number of ball bearings, are of great interest. Owing to lack of space it is not, unfortunately, possible to give full particulars of these tests, but, according to the results as given by the Ball Bearing Company, of Boston, they seem to point to the following conclusions:—(1) That friction increased little, if any, with the increased pressure; and (2) that friction increased considerably less than in the proportion of the square root of the speed.

The tests were made with bearings $2\frac{1}{6}$ in. and $2\frac{1}{2}$ in. diameter, and each test lasted from one to two days. The co-efficient of friction developed was from .0025 to .005, and these figures were obtained under comparatively light

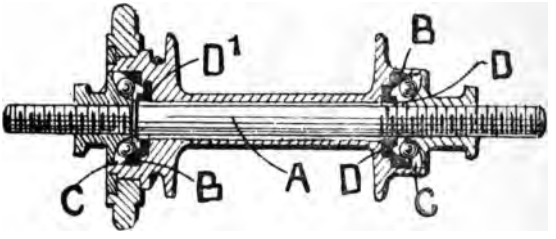

FIG. 44.—Premier Cycle Co. Hub.

loads. It will be seen that the first of these conclusions indicates a conformity to the laws of fluid friction, agreeing indeed with many recent experiments with ordinary bearings running with ordinary working loads and with flooded lubrication.

Figs. 42 and 43 illustrate two forms of the "Æolus" ball bearing, which are, it will be seen, adjustable concentrically. Referring to Fig. 42, A is the axle, B is a collar fixed upon the latter, and having a circumferential groove B^1, forming a path or race for the balls or spheres C; D is a concentric casing intended to be secured to the framework of the machine, and which is closed at one side, after the insertion of the balls, by a screwed gland D^1. Both the internal surface of the gland D^1, and of the casing D, are coned as shown, and the said cones can be adjusted relatively to the

balls by screwing in the said gland. In the pattern shown in Fig. 43, two cones D[1] and D[2] are screwed in from opposite sides of the casing D.

Of later types of ball-bearings for cycle wheels, the two most common patterns are what is known as the cup and cone, and that called the barrel or disc-adjusting hub.

Fig. 44 illustrates a hub made by the Premier Cycle Company, adapted for tangent spokes. A is the axle; B, B are the cones or ball-races which are secured in the cups C, C. A special feature of this hub is the provision of the L-shaped extractor rings D, D, which are placed in position

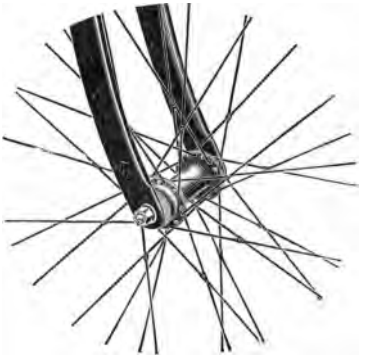

FIG. 45.—Rudge-Whitworth Limited Hub.

before the cones B, and which are screw-threaded as indicated at D[1]. To remove the cones B, a drift correspondingly externally screw-thread is passed in, the axle being of course first removed, and being screwed into the said extractor rings D, the latter together with the cones B can be easily got out.

Fig. 45 shows the exterior of a front wheel bearing with perfectly dust-proof hub for tangent spokes, of the pattern made by Rudge-Whitworth Limited.

The barrel or disc-adjusting hub, which is the type being now more generally fitted to high class machines, is somewhat more expensive to make than the older patterns, but

the additional cost is amply repaid by its lightness and other superior qualities. A hub of this description is illustrated, partly in vertical central section, in Fig. 46. A is the spindle or axle; B is a tubular piece or barrel forming the hub, which latter is provided with the flanges B^1, arranged in this instance for tangent spokes, and which barrel is also fitted with a lubricator C; D is the chain or sprocket wheel, which is screwed on to the tubular piece or barrel B, with a left-handed thread, and is firmly held in place thereon by a locking ring or collar D^1, screwed on to a reduced portion of the said barrel B, with a reverse thread. Upon each extremity of the spindle or axle A, and preferably upon a reduced portion thereof, is screwed a cone

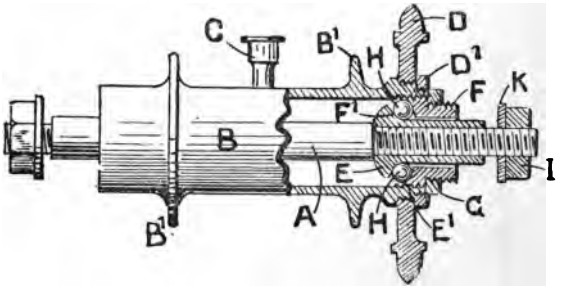

FIG. 46.—Barrel or Disc-Adjusting Hub.

piece E, upon the outer side of which is a ball-race or path F^1. F is a collar or disc upon which is another ball race or path E^1, one of which discs or collars is screwed into each end of the tubular piece or barrel B. The collars or discs F, as also the locking ring D^1, are usually provided with holes for admitting of this operation being effected by means of a pin-spanner or peg-wrench, or flats may be formed upon the end of the said discs or collars to allow of their being manipulated by means of an ordinary spanner. The discs or collars F can be adjusted by screwing them in or out of the said tubular piece or barrel B, and when the proper position has been attained, they should be locked in position by the back or locking nuts or rings G, which latter

may also be arranged for the use of a pin-spanner for tightening or the reverse. H, H are the balls or spheres, which are shown in position, between the ball races or paths E^1, F^1. The fork ends are passed over the extremities of the spindle or axle A, and are clamped or held against the projecting ends of the cone pieces E by the nuts I, either washers K, or the ends of the mud-guard stays, when the latter is fitted, being first interposed. The usual number of balls or spheres H, placed at each end of the hub, is ten, or twenty in all, and one of the said ends is a counterpart of the other, except that a chain or sprocket wheel is of course only fitted at one end thereof.

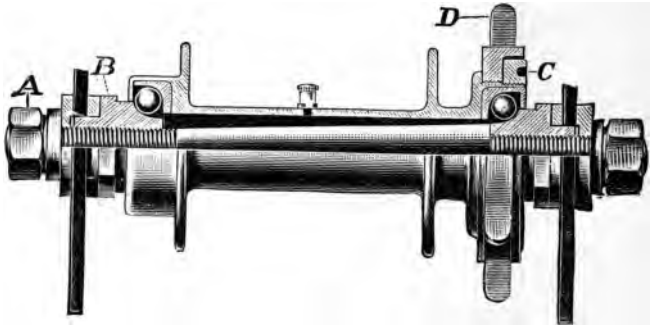

FIG. 47.—Humber Dust-proof and Oil-retaining Hub.

The hub for the front or steering wheel of a rear-driving safety bicycle only differs from the above in the absence of the chain wheel.

Fig. 47 illustrates a Humber dust-proof and oil-retaining hub of the latest type. The drawing shows a rear or driven wheel hub, partly in vertical longitudinal central section, the details of construction being thus made apparent. D is the chain or sprocket wheel which is screwed upon the barrel against a suitable shoulder or collar with a right-handed thread. C is a locking nut or collar, which is screwed upon a reduced portion of the said barrel with a left-handed thread, holes being provided therein for operating same through a pin-spanner, so as to clamp or fix the sprocket

wheel D firmly in position. The arrangement of the ball races and cones will be readily understood from the drawing. To adjust the bearings the nut A, shown on the left hand side of the hub, must be first slackened, and the loose cone B screwed up by means of the cone wrench, until all side shake or play is taken out of the wheel, the cone being then locked by again tightening up the said nut A. The front wheel hub is exactly similar, and is adjusted in like manner, the sprocket wheel being, however, of course absent in the latter case.

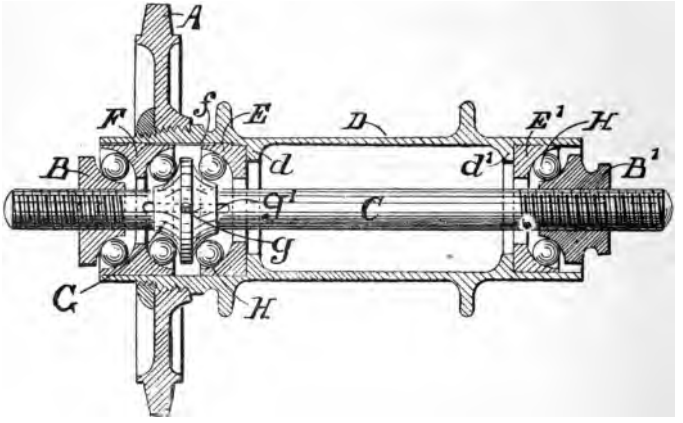

FIG. 48.—Preston Davies Adjustable Hub.

Fig. 48 is a vertical central section, showing an improved hub, patented in 1894, No. 11,379, by Preston Davies. The special features of novelty in this hub are the arrangement of the adjusting collar and the movable or adjusting cone in connection with three rows of balls, fixed ball races or paths, and adjustable end cones. In the drawing C is the spindle or axle, D is the tubular piece or barrel, having flanges D^1, for the attachment of the spokes; A is the chain or sprocket wheel, which is screwed on to the tubular piece or barrel D, and locked in position by means of a ring or collar as in the previous patterns. d, d^1 are fixed collars either formed on or firmly secured to the tubular piece or

barrel D, which collars form a support for the ball races or paths E, E^1. G is a double conical piece, forming two ball races or paths, and so mounted upon the spindle or axle C, by means of a pin or screw g, and slot or key way g^1, as to be free to move lengthways of the said spindle or axle C, through a certain distance, for purposes of adjustment, but at the same time to be obliged to rotate therewith. F is a disc or collar, also having two ball races or paths, and B, B^1 are cone pieces, having inner ball races or paths. The disc or collar F is screwed into the tubular piece or barrel D, and the cone pieces B, B^1 are screwed upon the spindle or axle C. It will be seen that two rows of balls are mounted between the ball race or path E, the double cone G, and the inner ball race or path on the disc or collar F; and another or third row of balls is mounted between the outer ball race or path on the latter, and that on the cone piece E. A fourth row of balls is mounted between the ball race or path E^1, and that on the other cone piece B^1.

This hub is an improvement upon that described in a former patent granted to Mr Davies, viz., No. 17,407 of 1892. An important feature in the invention is the provision of the treble rows, or other compound arrangements, of balls at that end of the hub whereat the strain of the driving chain is experienced. In ordinary hubs with a single row of balls at each extremity, the wear upon that side carrying the chain or sprocket wheel is found to be excessive. The provision of three rows of balls equalises the said wear, and consequently renders the hub longer lived than would otherwise be the case, and furthermore prevents it from getting out of truth, and obviates all shake or end play. The double conical piece in combination with the ball races or paths admits of this compound or multiple arrangement of balls being efficiently adjusted when required.

Fig. 50 illustrates one of the many patterns of elongated dust-proof front or steering wheel hubs made by Perry & Co. Limited. It is constructed of the best cast steel, and very accurately finished.

Fig. 51 is a vertical central section through a new hub designed by Harry James, which forms the subject-matter of a patent granted in 1893, No. 2,516. A and A^1 are

hardened steel cups or cone pieces screwed into the body or barrel of the hub. B is a hardened steel bush screwed upon the spindle F, and having an annular groove forming a race for the balls G. To take up any slackness caused by wear or otherwise, the bush B is screwed outwardly on the

FIG. 50.—Perry & Co. Ltd. Elongated Dust-proof Hub.

spindle F, the adjustment of the other side of the hub being effected in a similar manner. All the wearing parts of the hub are, it will be seen, thoroughly hardened, whilst the whole of the body and of the axle are left soft. The hub is perfectly dust-proof and oil-retaining. In the illustration

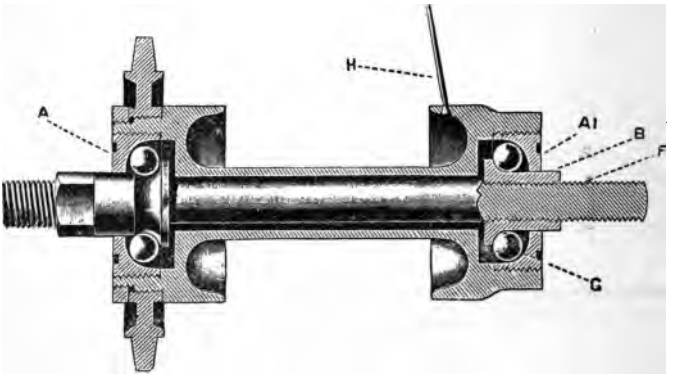

FIG. 51.—Harry James Adjustable Hub.

the hub is shown fitted with direct spokes H, but is also made with flanges suitable for laced or tangent spokes.

As in the previous cases, the front or steering wheel hub need only differ from that illustrated by the dispensation of the chain wheel.

Fig. 52 illustrates a hub for cycles, designed by A. Kotin and A. J. Wallis-Tayler (No. 6,745 of 1896), wherein rollers are substituted for balls, and in which, moreover, by mounting the axle eccentrically an attempt is made to facilitate the propulsion of the cycle by the reduction of friction. The

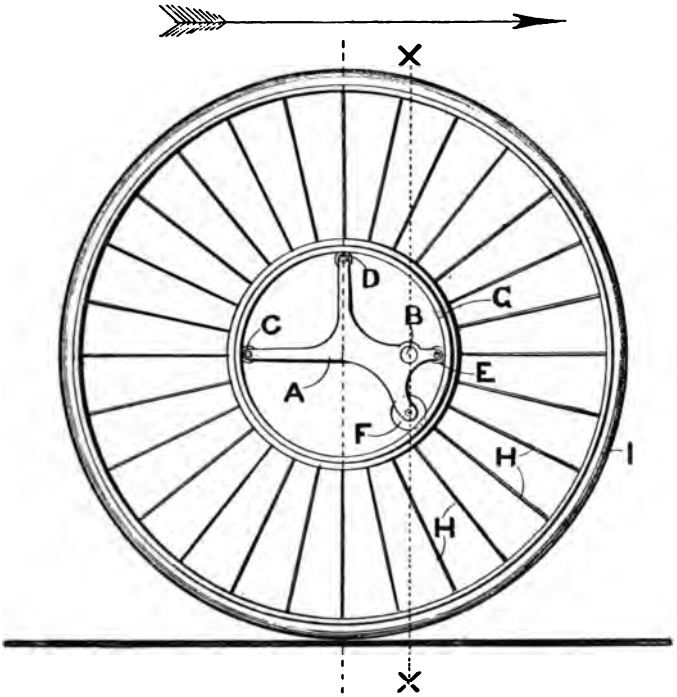

FIG. 52.—Kotin-Tayler Roller Hub.

construction of the device will be clear from the drawing. B is the axle, which is secured to a four-armed piece or bracket A, at the extremities of which arms are mounted small anti-friction rollers C, D, E, F. G is the hub, upon the inner surface of which is provided a path or race for the anti-friction rollers C, D, E, F. The hub G is secured to

the rim or felloe I by the spokes H in the usual manner. It will be seen that the centre of gravity will pass through a point considerably in advance of the centre line of the wheel, as indicated by the dotted line X X, and as there must of necessity be a slight clearance between the rollers C, D, E, and the path or race, owing to the weight being carried upon the roller F, upon the propulsion or traction of the vehicle in the direction indicated by the arrow on the drawing, the weight to be carried by the wheel being, as just mentioned, entirely borne upon the roller F, and the axle being consequently practically placed eccentrically, a large portion of the said weight would be utilised to assist in the rotation of the wheel.

In the case of the driving wheel of a cycle, one of the anti-friction rollers (preferably F) could be advantageously utilised for driving purposes, the axle thereof being extended, and carrying a gear, chain, or sprocket wheel, to which motion could be imparted in the usual manner by a pitch chain from the chain or sprocket wheel upon the crank axle. In another arrangement for driving, the roller F might be duplicated, and the peripheries of each of them formed V-shaped, and arranged to run in corresponding circumferential internal grooves provided at each side of the path or race. Instead of the above V-driving gear, a toothed wheel, gearing with an internally toothed ring formed on or secured to the hub G, could be employed. The toothed wheel to be preferably mounted on the axle of the roller F, and a chain wheel be likewise secured upon the outer end of the same axle.

In a patent taken out by J. S. Prentice, W. Renison, and J. Renison, in 1891, No. 20,317, an attempt was also made to facilitate propulsion by throwing the centre of gravity in advance of the centre of the wheel. In this case the arrangement, which is confined to the rear or driving wheel, consists in a somewhat complicated and awkward device for supporting the weight of the saddle, and consequently of the rider, upon a small wheel or roller arranged to run upon a path or race formed upon the inner surface of the rim or felloe. The said wheel is mounted upon the lower end of a rod connected at its other or upper extremity to the upper or top stay, and bears upon the said rim or felloe somewhat

in front of a perpendicular line drawn through the centre of the axle. The wheel is provided with the usual hub, and is driven by chain gearing in the ordinary manner.

A. Bodding, No. 7,391 of 1894, employs an enlarged hub having a roller race or path, which arrangement he holds would create a considerable saving in friction. No attempt, however, is made to support the weight upon a point in advance of the centre of gravity of the wheel.

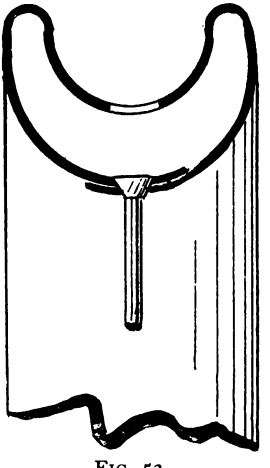

FIG. 53.

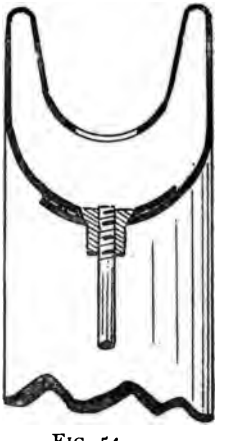

FIG. 54.

Warwick Hollow Metallic Rim or Felloe.

RIMS.—Solid metallic rims are made out of lengths of steel, crescent shaped in transverse section, which are brought to the requisite circular shape by passing them through a set of bending rolls of the usual description generally employed for that class of work. The ends are united by brazing, the joint being first scarfed and pinned or riveted together, as will be more carefully described in the chapter on the Construction of Cycles.

The Warwick hollow metallic rim or felloe (patent No. 4,597[82]) is shown in Figs. 53 and 54, which represent two forms or modifications thereof, the construction of which

will be very readily understood from the drawing, wherein they are shown in transverse section. These metallic rims or felloes are made from single strips of sheet steel by drawing or rolling, or by the drawing and rolling processes combined, and afterwards made into tubing so fashioned that it will have on one side a trough of nearly semi-circular figure, wherein the indiarubber or other tyre fits, and at its other side will be of nearly elliptical figure. The edges of

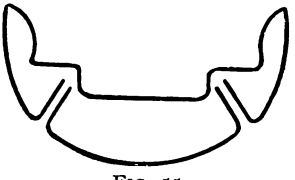

FIG. 55.

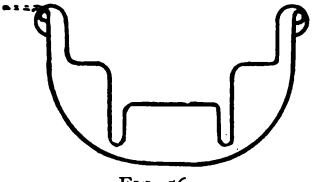

FIG. 56.

Warwick Hollow Metallic Rim or Felloe.

the sheet are overlapped at the last-named side, and are brazed or soldered so as to give great strength and rigidity to the rim or felloe at that part where the spokes are connected to it. This rim or felloe is constructed of several other forms in transverse section. Figs. 55, 56, and 57 show three other forms of hollow rims, which constitute the subject-matter of a subsequent patent granted to the same inventor—No. 8,407 of 1894.

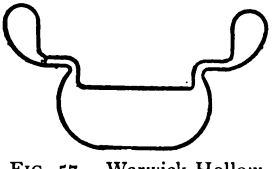

FIG. 57.—Warwick Hollow Metallic Rim or Felloe.

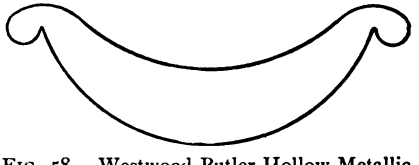

FIG. 58.—Westwood-Butler Hollow Metallic Rim or Felloe.

In the later patterns of Warwick hollow rims the joints are made at the exterior faces thereof instead of at the interior ones, as shown in Figs. 53 and 54. The said joints, moreover, are scarfed instead of ordinary lapped joints, as shown in the above figures.

The hollow metallic rim or felloe known as the "Westwood," which was patented by Frederick Westwood and

William Henry Butler in 1890 (No. 2,202), is shown in Fig. 58. It is made as follows:— A V or U-shaped rim of the ordinary pattern is first rolled or otherwise formed, but with an additional flange or border rolled or otherwise formed on each edge, and turned outwards in a spiral form, so as to produce a flat flange or otherwise. A second rim or tube of smaller diameter than the first, and flanged on the edge, is then so placed in connection with the above before the spokes are inserted that there will be a space or clearance

FIG. 59.—Westwood Metallic Rim.

FIG. 60.—Sparkbrook Hollow Metallic Rim or Felloe.

between the two rims or felloes, which are then secured together by semi-circular or other suitably shaped pieces of metal. The tyre is intended to be carried upon the first or outer rim, and to be made or vulcanised in position thereon, and held in the centre so that the sides may be displaced to insert the spokes. The latter are either fastened in the inner rim, or they are passed through the latter, and secured to the flanges in the outer rim. A later pattern Westwood rim is illustrated in Fig. 59.

Fig. 60 is a perspective view, and Fig. 61 is a transverse section, illustrating a Sparkbrook hollow metallic rim or felloe of the latest design, the construction of which will be clearly seen from the said drawings. The following advan-

tages are claimed for it by the makers, viz. :—That it is absolutely true and round, and consequently makes a perfect wheel, and in building allows all the spokes to be drawn to an equal tension. By reason of its particular shape it is the easiest rim from which to detach the tyres of the so-called Dunlop type, whilst at the same time it holds the tyre so firmly that there is not the least chance of its blowing off

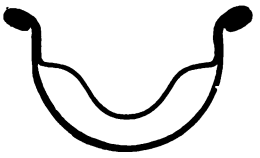

FIG. 61.—Sparkbrook Hollow Metallic Rim or Felloe.

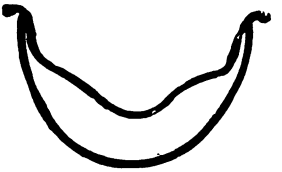

FIG. 62.—James Hollow Detachable Rim.

when fully inflated. There being five thicknesses of steel folded at the edges, the tyre possesses great lateral stability, and renders it almost impossible for the rim to be damaged by any obstacle, such as a large stone, with which the wheel may come in contact upon the road. The rim is, moreover, invariably constructed of very high grade steel.

Four patterns of J. T. James's rims are shown in Figs. 62, 63, 64, and 65. That illustrated in Fig. 62 is a hollow

FIG. 63.—James Hollow Continental Rim.

FIG. 64.—James Inside Bead Rim.

detachable rim ; Fig. 63 is what is known as a hollow Continental and Palmer rim ; Fig. 64 is a rim having an inside bead ; and Fig. 65 is a registered design of single rim.

Many other forms of hollow metal rims or felloes, either built up of two strips of steel rolled to a proper section, and united by brazing, or rolled out of a length of solid drawn mild steel tube, are made by various manufacturers, which space does not admit of noticing.

Wooden rims are much used in the United States, and

many of the leading manufacturers there claim that they are fully as trustworthy as steel, if not more so, whilst possessing at the same time many undoubted good qualities, not the least of which are great lightness and elasticity. Maple,

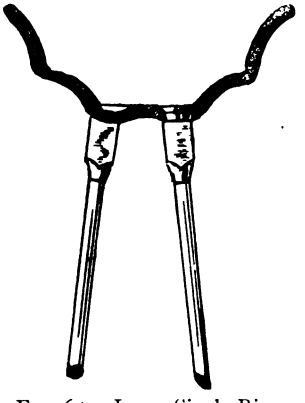

FIG. 65.--James Single Rim.

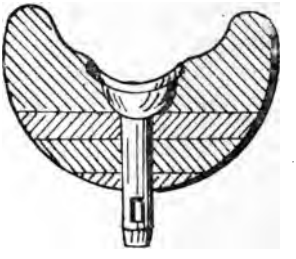

FIG. 66.—Boston Laminated Wood Rim.

hickory, elm, and ash are good woods for the purpose. Makers in this country, as a rule, refuse to guarantee wooden rims.

Fig. 66 is a transverse section through a laminated wood rim, known as the "Boston." Rims of this type are built up of several layers or thicknesses of wood. The wooden

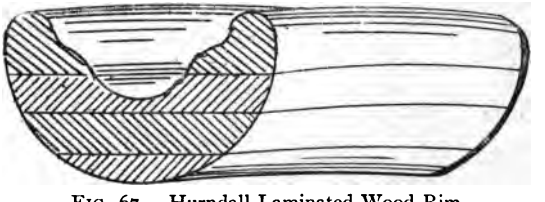

FIG. 67.—Hurndall Laminated Wood Rim.

rims or felloes should be given numerous coats of varnish both before and likewise after the spoke holes are bored, so as to thoroughly protect the material from the effects of moisture. Fig. 67 is a perspective view showing a section of the Hurndall wood rim for Dunlop or single tube tyres.

Fairbanks' British patent for built-up waterproof wood rims is No. 742 of 1893.

Various other forms of rims or felloes will be found illustrated in connection with tyres; and it may be here remarked that the exact designs of the various rims are being constantly changed, and that they seldom closely resemble those shown in the patent specifications.

SPOKES.—As has been already mentioned, from the date of the introduction of the wire spoke the cycle began to be

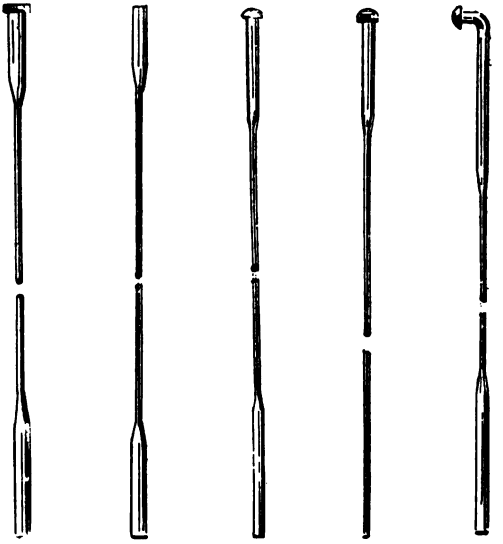

FIG. 68. FIG. 69. FIG. 70. FIG. 71. FIG. 72.
Various Patterns of Wire Spokes.

a vehicle capable of being propelled not only with speed, but with great comfort to the rider. Figs. 68 to 72 show various ordinary patterns of wire spokes. A leading firm in the manufacture of spokes is D. F. Tayler & Co. Limited.

The first wire spokes used were of the straight direct radial type, which were threaded through holes in the rim, and were screwed direct into the flanges on the hub. In Harrington and Brent's provisional specification, No. 869 of

1879, is described a method of mounting wire spokes in the hub of a cycle wheel by making a rivet head at one end of each of the spokes, and threading the said spokes through thimbles or bushes closely fitting such spokes. These thimbles or bushes are each provided with a flanged head, against which the rivet head of the spoke abuts. They are passed, but not screwed, through holes formed for them in projecting rings or flanges attached to the hub. The other ends of the spokes may be fixed in the metal tyre or felloe of the wheel in any suitable manner. When employing a rivet head on the other end of the spoke, such rivet head is formed after the thimble or bush is applied thereto.

In 1883 a patent (No. 5,433) was granted to Edward Charles Frederick Otto for undulating or helical tensional spokes. These spokes were corrugated or crimped throughout their entire length. The effect of these undulations was said to impart a certain amount of elasticity to the wheel. For some few years spokes of this type were used to a certain extent, and were said to give favourable results, both as regards efficiency and also as regards capability of withstanding the shocks to which the wheels of cycles are inevitably subjected when in use on average roads. These spokes are not now used, and indeed any contrivance for rendering the wheels springy is rendered unnecessary by the universal, or nearly universal, use of pneumatic tyres. At present the majority of wheels are fitted with tangent spokes, which pattern afford the advantage of obviating the windage which takes place with direct spokes before the power can be transmitted through the spokes to the rim. Originally the spokes were in this case made in pairs, each of which pairs was threaded through a hole in the flange of the hub, the free ends being secured to the rim by means of nuts or nipples. Stevens employs hickory as a material for spokes.

Fig. 45 illustrates an arrangement wherein single spokes are threaded through transverse holes in the hub, and are then bent to run off at right angles to the said hole, forming as it were a sort of hook, the spoke ends being likewise headed, as shown in Fig. 72, to prevent them from pulling through the holes, and being fixed to the rim by nuts or nipples. Besides the above-named advantage, tangent spokes afford that of being much easier to replace when damaged

and repairs become necessary, as will be seen later on when dealing with that subject.

J. W. Hall and H. L. Phillips, in a patent, No. 13,191 of 1887, describe a method of mounting wire spokes in cycle wheels by fitting them in a circular groove in the hub, a single length of wire forming two spokes. To place the wire in position the middle part is passed through the circular groove, and the ends of it are adjustably fixed to the rim or felloe. These circular grooves can be formed either in the outer or inner faces of the hub flanges, and to retain the wires in position therein are either undercut on their inner sides, so as to leave central conical portions, the apexes of which are placed inwards, and the bases to the exterior, so that they are of smaller diameter where the wires are taken round them, or the said grooves may be cut or formed with parallel sides, and covered by plates to keep the wires from slipping out. Instead of each length of wire forming two spokes, each length of wire can have an eye to secure it in the groove, and thus form a single spoke. If the grooves are so formed as to just cut the periphery of the hub, the spokes would be tangential, whilst if they are struck from points in the periphery, they would be radial.

Wheels have been built fitted with many different numbers of tangent spokes, but unless the number of the latter be some multiple of 8, they are bastard, and not true tangent-spoked wheels. For the standard rear-driving chain safety, as at present constructed, the almost universal rule is to fit the rear or driving wheel with forty spokes, and the front or steering wheel with thirty-two spokes. In inserting the spokes, starting from the hub of the wheel, they are made to cross each other; entering the tenth hole in the rim, nine holes would thus at first be vacant in the rim between the two spokes that cross upon one side of the flange of the hub, and three holes would be left between adjoining spokes in the same direction. The remainder of the spokes are placed in position in a similar manner.

The weak point in tangent spokes is where they are bent in the hub of the wheel. The spokes are usually secured at the points where they cross by wrapping them with fine wire and soldering. Another method, however, said to give better results, and which has been invented by C. T. Austen, is

to pass on every two spokes a copper or other nipple, or short piece of thin tube, which is sufficiently ductile to bend when the said spokes are spread apart. This nipple is then secured firmly in position by a drop of solder. The best material for the purpose of spoke-making is pianoforte wire, and good spokes will stand over 60 tons per sq. in.

SPRING WHEELS. — Various forms of these have been devised at different times, the most successful being perhaps those wherein flat or ribbon springs are bent into a shape resembling that of a Jew's harp, the round parts being riveted

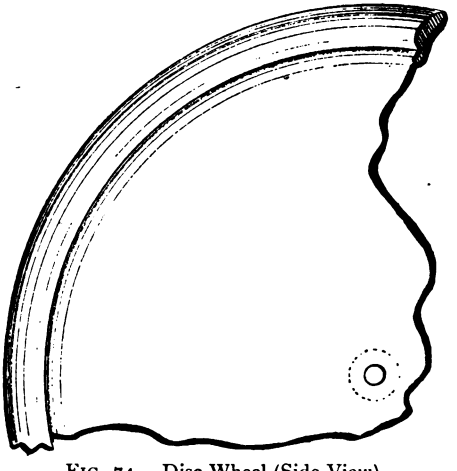

FIG. 74.—Disc Wheel (Side View).

or secured to the rim or felloe of the wheel, and the parallel and adjacent ends to the hub.

DISC WHEELS.—A form of wheel wherein the spokes are entirely dispensed with is the disc wheel. This idea is, of course, by no means a new one, so far as the making of the wheel in disc form is concerned, as most primary wheels for vehicles must of necessity have been so built, spokes only being introduced at a later period, and as an improvement, but the adaptation of the principle to light metallic wheels, such as those of cycles, necessitated certain specific improvements in details of construction.

As early as 1878, a patent was taken out here by E. C. Otto and J. Wallis, No. 2,774, for sheet metal concave disc wheels. Briefly, their wheel was formed of two slightly concave sheet metal discs, which might be cut away or perforated in any suitable manner for lightness, and the peripheries of which were so shaped that when the two discs were secured together a convenient recessed rim or felloe was formed for the reception of a suitable tyre.

A later patent granted to G. L. Morris, W. T. Wilson, and N. H. Strickland, No. 5,767 of 1890, describes a disc wheel such as that shown in side elevation in Fig. 74, and in transverse section in Fig. 75, which is formed of sheet metal, or other suitable materials, for instance papier-mâché, wood, cardboard, &c. The wheel is, as shown in Fig. 75, formed of two concave or saucer-shaped discs, so placed that their concavities will face or be opposite to each other, and the peripheral edges of which are united together, as shown, at the rim or felloe.

FIG. 75.—Disc Wheel (Trans. Sect.).

These disc wheels, even when considerably cut away or perforated, are heavier than wheels with wire spokes. They have been also found in practice to be very liable to buckle, to counteract which latter defect they were subsequently formed with corrugations. They are likewise obviously unsuitable for side winds, offering a considerable obstruction thereto even when perforated. Another objection to disc wheels, which does not, however, affect their efficiency, and is therefore one of minor importance, is that they create a humming or whistling noise when rotated at any velocity.

TYRES.—The small $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$ inch, and other solid rubber tyres are no longer fitted to new machines, and are now consequently seldom met with; and the $1\frac{1}{4}$, $1\frac{1}{2}$ inch, and other cushion tyres are also fast becoming replaced by pneumatic or air tyres, the use of which latter has now become almost universal.

From time to time, indeed, attempts have been made to devise, and introduce a spring tyre that would have all the advantages of the air tyre without the attendant disadvantages of the latter of liability to leakage and deflation from punctures, through or round the inlet or charging valves, and of bursting if inflated to an injudicious extent. Whilst possessing certain well-defined advantages, however, all the patterns of spring tyres hitherto devised, or indeed, that it would seemingly be possible to devise, must obviously fail to afford the one great benefit derived from the use of pneumatic or air tyres, viz., that instead of having to surmount the small obstacles that are encountered upon the surface upon which they are travelling, the said obstacles become temporarily, partially, or completely absorbed by the tyres, and the wheels are thus enabled to pass over them

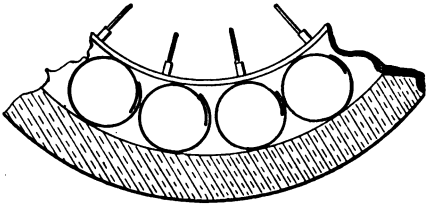

FIG. 76.—Wallis-Tayler Spring Tyre.

with little or no shock being experienced. The retardation of the cycle, by reason of such impediments, and the increased difficulty of propulsion owing thereto, are thus reduced to a minimum.

The spring tyres above mentioned usually comprise some arrangement of springs suitably placed or mounted between the rim or felloe of the wheel and the tread, which is in this instance generally formed of metal, with or without a second or outer tyre of indiarubber or other suitable material thereon. These springs take the form of spiral springs set radially between the rim or felloe and the tyre, and secured to both of them; spiral springs intertwined together or placed closely side by side in the said space; flat or ribbon springs, each of which is bent into the form of the letter S, and which are placed lengthways at proper intervals, between

the rim or felloe and the tyre, and secured to both, or which are packed in the said space or clearance without fastening. Many other forms of springs have also been suggested or tried from time to time.

Fig. 76 illustrates a portion of a wheel with a tyre of this description, designed by the author, in which, as will be clearly seen from the drawing, the springs consist of flat rings, the ends of which are not joined, but are left free and overlapping. These spring rings may be either packed round the space or clearance between the rim or felloe and the outer portion of the tyre, or they may be secured by rivets or distance pieces in the said space at suitable intervals apart. The outer portion or ring of the tyre is of metal, and the tread of indiarubber or other elastic material.

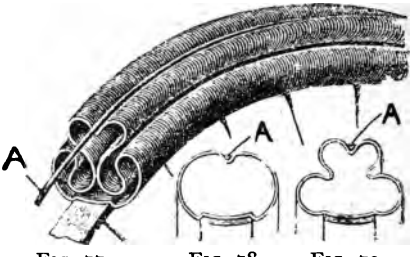

FIG. 77. FIG. 78. FIG. 79.
Honrath Spring Tyres.

Figs. 77, 78, and 79 illustrate various forms of spring tyres patented in the U.S. in 1895, by Alexander Honrath. They are constructed of spring wire either in sections, or as a series of continuous or connected members, presenting a base section adapted to fit upon the rim or felloe of the wheel. When in contact with the ground, the outer surface expands under the pressure. A, A are tie rods or wires fitting in a central recess in the outer surface of the tyre, and holding the sections firmly together. The tyre is preferably provided with a leather, indiarubber, or other outer covering or casing.

As already mentioned, tyres of this description cannot compete with pneumatic or air tyres, as they are not only incapable of passing over any obstacles or inequalities on

the surface with the same amount of ease and absence of shocks, but are not endowed with anything like the same amount of resilience.

Pneumatic or air tyres may be divided as regards construction into three main classes, viz. :—First, those of the single tube or hose pipe pattern; second, those known as built-up tyres, wherein an inner inflatable tube is provided, and an outer covering to restrain or keep the latter within bounds; and third, those known as tubeless tyres wherein no separate internal inflatable tube is provided, and the tyre does not form an air-tight tube until fixed in place upon the rim or felloe of the wheel. As regards the mode adopted for securing them in position upon the rim or felloe, cementing, lacing, and other methods have almost entirely given place to two plans or systems of fastening, viz., that wherein the tyre is held in place by means of wires, and that wherein thickened edges or beadings thereon are held or gripped in dovetail grooves upon the rim or felloe when the tyre is inflated, or wherein a wedging action is otherwise set up on inflation.

Pneumatic or air tyres are by no means a modern invention, a patent* having been obtained for them in 1845, No. 10,990, by R. W. Thomson, an inventor whose ideas were many years in advance of his time, and whose inventions consequently fell to the ground.

Pneumatic or air tyres were reinvented forty-three years after the date of the above, by J. B. Dunlop, who took out a patent in 1888, for what may be presumed to be a pneumatic tyre, but no drawings were filed with his specification, and the text is very vague and indefinite. In a subsequent patent granted to the same inventor in 1889, No. 4,116, a description is given of a pneumatic tyre intended to be secured to the rim or felloe of the wheel by cementing. This tyre is illustrated in Fig. 80. A is the inner tube of the tyre, which, as will be seen from the drawing,—which represents a transverse section through the said tyre and the rim or felloe of the wheel,—is strengthened by an outer layer

* The matter contained in this patent is so interesting that we give a verbatim copy of the specification, and a reproduction of the drawings accompanying it, in an appendix to the book. The official edition of the specification at the time of writing was out of print.

of indiarubber B, thickened at the tread, and also by layers of linen or canvas C and D, cemented to the inner tube A, and to the rim or felloe E of the wheel, the latter being likewise covered by linen or canvas F, and by elastic strips G, to prevent its edges from damaging the tyre. A valve such as that shown in Fig. 81, which was likewise patented by the same inventor in 1889, No. 4,115, was intended to be used with this and other pneumatic tyres. The construction of this valve is very simple, but it is nevertheless ingenious and effective. It consists essentially as shown of an india-rubber inflation tube A, containing a grooved cylindrical plug B, so retained in the said tube by a strap C, placed

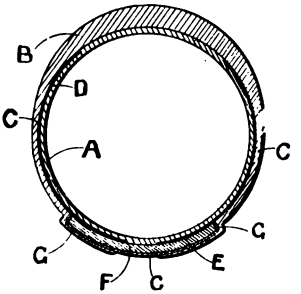

FIG. 80.
Dunlop Pneumatic or Air Tyre.

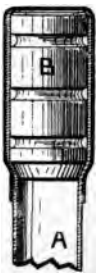

FIG. 81.
Dunlop Pneumatic Valve.

across the tube mouth, and the ends of which are cemented to the said tube, that it cannot be blown out without actual rupture of the said strap. This valve projects into the tyre, so that the air, after passing in by expanding the tube round the said plug B, prevents its own return by forcing or pressing the indiarubber tube against the latter.

Several other patents* have been subsequently taken out by this inventor for improvements in pneumatic or air tyres. None of these tyres, however, are worth describing and illustrating; and it may here be remarked that the phenomenal success of the company manufacturing what are known as the Dunlop tyres is practically entirely due to the unsurpas-

* Nos. 17,470 of 1890; 13,230, 1,554, and 19,838 of 1891; 12,957 of 1892; and 11,820 of 1893.

sable generalship of Harvey du Cros, the managing director, a gentleman to whose untiring energy indeed the first introduction of the pneumatic tyre, in the face of much ridicule and opposition, was due. The Dunlop Pneumatic Tyre Company Limited own a number of other patents for really first-rate pneumatic tyres, all of which, however, are known under the generic title of Dunlop tyres. They will, however, be here dealt with under the names of their inventors.

Fig. 82 is a transverse section showing the Boothroyd roadster tyre, which is one of the single-tube or hose-pipe pattern. Fig. 83 illustrates another tyre of this type made by Morgan & Wright. Another single-tube or hose-pipe tyre much used is the Hartford; and that known as the "National" is also a good tyre of this class.

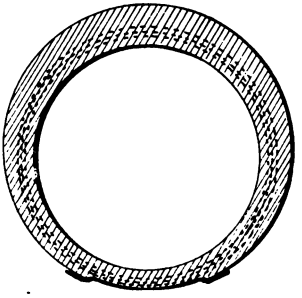

FIG. 82.—Boothroyd Roadster Single-Tube Pneumatic Tyre.

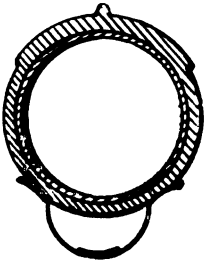

FIG. 83.—Morgan & Wright Single-Tube Pneumatic Tyre.

Fig. 84 illustrates an inner inflatable tube, wire-attached tyre, patented by C. K. Welch in 1890, No. 14,563. As will be seen from the drawing, the indiarubber tyre or tread A is of an arch or saddle shape in transverse section. This saddle-shaped tyre is applicable to the peripheries of ordinary rubber types of the solid cushion or pneumatic type. It is, however, shown in the illustration fixed upon a tyre of the latter description. The method of securing the tyre A in position upon the rim or felloe B, over the ordinary pneumatic tyre C, is by wires D, which are preferably enclosed in loops E^1, on a canvas strip E. The ends of the wires D are secured together by brazing before the tyre is placed upon the rim; and when in position thereon the said

wires fit against shoulders B[1], formed in the metallic rim B. Preferably the saddle-shaped piece A is moulded with its edges close together, so that they have to be spread apart when applied, thereby compressing the tread of the tyre, and reducing the liability to puncture. For some forms of rims the ends of the fastening wires are secured by a long nut or internally screwed nipple.

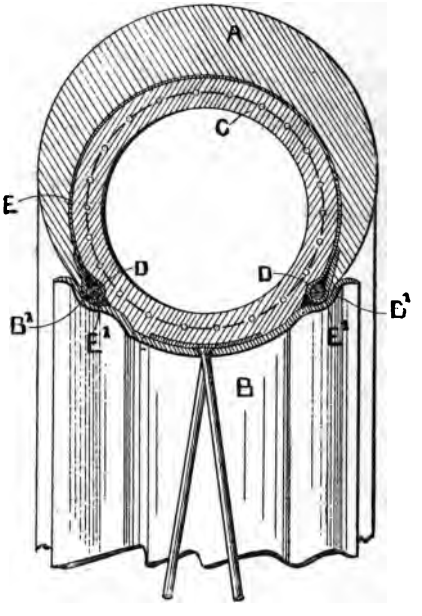

FIG. 84.—Welch Built-up, Wire-attached Pneumatic Tyre (Early Form).

To place a tyre of the first description, wherein the fastening wires are secured by brazing before it is in position on the rim or felloe, one side is partially passed over the rim, and into the central concavity of the said rim, and the remaining portion of that side is then easily levered over the edge thereof. The other side is got in position in like manner, and the inflation of the tyre maintains the said wires in the position shown against the shoulders B[1]. The

form of the rim in transverse section must in this case be such as to afford the requisite central depression or groove into which to first place the wire. The operation would be further facilitated, and rendered still more easy, by the employment of spring wires, several forms of which have been devised for this purpose. Fig. 85 shows one of the most recent patterns of Welch tyres.

An interesting feature in Welch's patent is that no mention whatever seems to have been made in his provisional specification of pneumatic tyres, although of course this type of tyre forms the most important point in his complete specifi-

FIG. 85.—Welch Built-up, Wire-attached Pneumatic Tyre (Modern Form).

cation. The most careful and expert scrutiny, indeed, of the provisional specification does not appear to show that he had therein foreshadowed even in the slightest degree the pneumatic wire-secured tyre as made under his patent and described and illustrated in the complete specification. In spite of this, however, and other apparently fatal flaws, in the case of The Pneumatic Tyre Co. *v.* Casewell, lately tried before Justice Kekewich, we have the judgment of that learned gentleman, since confirmed on appeal, upholding the patent.

Several other forms of wire-attached pneumatic tyres are also made. Figs. 86 and 86*a* show two forms of tyres manufactured by the Beeston Pneumatic Tyre Company Limited.

The first, which is very similar in construction to the tyre previously described, is known as the "Beeston Corrugated Tyre." The corrugations run lengthways of the tyre as shown.

The second is known as the "Beeston Oat Tyre," from the shape of the elongated lumps or excrescences formed upon the tread surface, as shown, to roughen it and obviate slip. These tyres formed the subject-matter of a provisional application by J. S. Simonds and J. T. French, No. 4,147 of 1878, and of a patent, No. 10,318 of 1888.

The tyre known as Scott's Standard tyre, which was designed by R. Scott, is practically similar to that shown in Fig. 86.

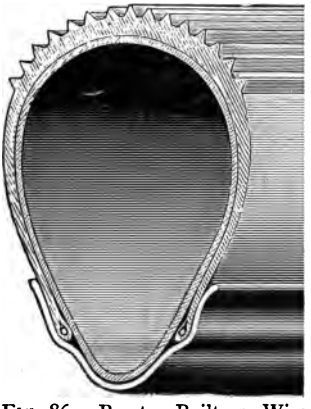

FIG. 86.—Beeston Built-up, Wire-attached Corrugated (Pneumatic) Tyre.

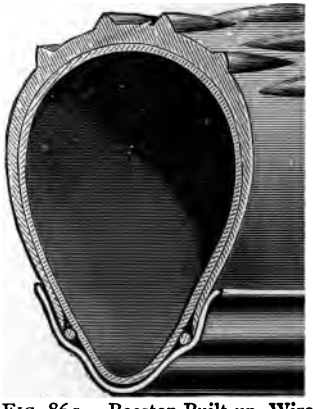

FIG. 86*a*.—Beeston Built-up, Wire-attached "Oat" (Pneumatic) Tyre.

Fig. 87 shows in transverse section a tyre made by the Hyde Imperial Rubber Company Limited, which is known as the "Woodley." It has three fastening wires as shown, one of which is for the cushion or flap. The outer cover, the inner or air tube, and the flap or cushioning strip of soft indiarubber, are indicated upon the drawing. This tyre has also a non-slipping tread as shown.

Another wire-fastened tyre in use is that of Warwick, and mention may also be made of Smith's "Record" tyre, of that known as the "Terminus," which is the design of M. Gouzenes, a French inventor, E. H. Seddon's, one form of

which had an auxiliary tube, and the Bagot Tyre, Patent No. 6,513 and 6,515A of 1896.

The construction of wire-fastened tyres is clearly shown in the above drawings, and will be sufficiently apparent without entering into more lengthy descriptions. The "Zenith" tyre has a flat chain fastening.

The method of fastening the tyres upon the rims or felloes without wires or cement, and wherein a wedging action, set up on inflation, is employed for that purpose, is becoming much used, and most decidedly affords many advantages, not the least of which is the extreme ease with which the removal and replacing of the tyres in position

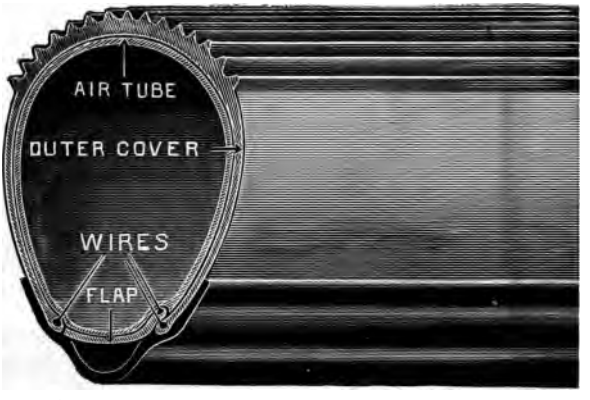

FIG. 87.—Woodley Built-up, Wire-Attached Pneumatic Tyre.

upon the wheel rim can be effected. An example of a tyre of this description is shown in Fig. 87*a*, a patent for which was taken out by W. E. Bartlett in 1890, No. 16,783. This tyre is of that type usually known under the name of the "Clincher." In the illustration, wherein it is shown in transverse section, A is an air tube capable of being inflated through a branch B. This inflatable tube A is secured to the metal rim or felloe C of the wheel by means of an arched-shaped strip D of indiarubber or other flexible material, the edges of which strip D are forced against the inturned or dove-tailed flanges of the said

rim or felloe C by the pressure of the air within the air tube when the latter is fully inflated. Fig. 88 illustrates a modern form of Clincher tyre as used in 1896.

Another tyre of this type, illustrated in Fig. 89, was patented by R. Scott in 1891, No. 4,108. A is the tyre, which is constructed of canvas and rubber, and provided at its edges with beads A^1; B is an internal air tube. The edges of the tyre are sometimes strengthened by means of leather. C, C are hoops which secure the tyre to the rim or felloe D of

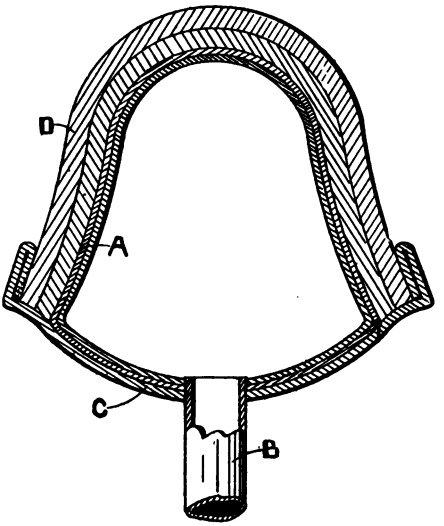

FIG. 87*a*.—Bartlett (Clincher) Wedge-action, Built-up Pneumatic Tyre (Later Form).

the wheel, the joints being held by screw clamps E. These rings are sometimes contracted by right- and left-handed screw arrangements, or they are formed in segments, secured together by set screws and clamps. In some arrangements the hoops are embedded in the edges of the tyres, and projecting studs for engaging in holes in the rim are employed, or the edges of the tyres may be provided with eyelet holes for engaging with projections on the rim.

Fig. 90 illustrates a type of tyre patented by J. F.

Palmer in 1892, No. 8,516. In this arrangement the air tube A is protected at the tread of the tyre by an india-rubber covering B, attached to a canvas strip C, which passes under the air tube, and is stitched together near its edges, so as to leave two projecting flaps c^1. An outer india-

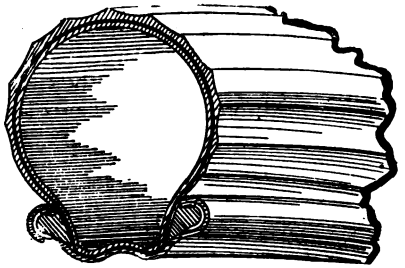

FIG. 88.—Bartlett (Clincher) Wedge-action, Built-up Pneumatic Tyre (Later Form).

rubber casing or covering D surrounds the tyre, and its enlarged edges are brought together at the centre of the rim so as to abut on the joint of the canvas strip C. The flaps c^1 are turned back so as to lie between the india-rubber casing D and the rim or felloe E of the wheel, and the edges of the latter are provided with beads which fit into grooves formed in the enlarged ends c^2 of the indiarubber casing. A piece of soft indiarubber is sometimes interposed between the inner portion of the air tube and the casing, as shown, so as to provide a cushion or buffer, also a loop of canvas intended to prevent chafing of the said cushion by the seam of the canvas strip C, or of the air tube itself in cases where the cushion is not employed.

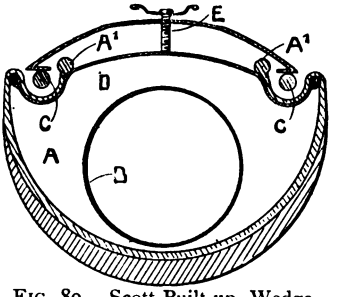

FIG. 89.—Scott Built-up, Wedge-action Pneumatic Tyre.

Two patents were taken out in 1892, numbered respectively 6,640 and 12,730, by Michelin & Co., for tyres wherein the enlarged edges of the outer covering are clamped or

clipped in position by means of rings. These patents, although only filed in this country in the above year, under the regulations of the International Convention, date back respectively to, the first, the 11th September, and the second, the 29th December 1891.

Fig. 91 shows a tyre patented in 1892, No. 19,481, by W. T. Shaw, J. W. Boothroyd, and A. Sydenham. The outer casing A of this tyre has enlarged edges A^1, which fit under the inwardly turned edges B^1 of the rim or felloe B of the wheel, and are held forcibly in place by the pressure of

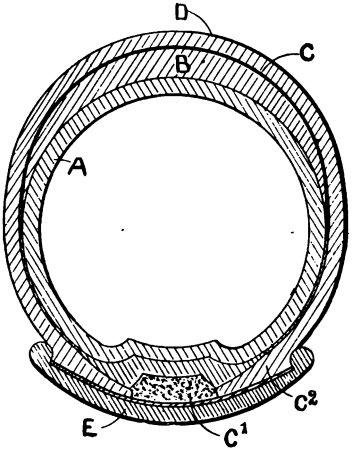

FIG. 90.—Palmer Built-up, Wedge-action Pneumatic Tyre.

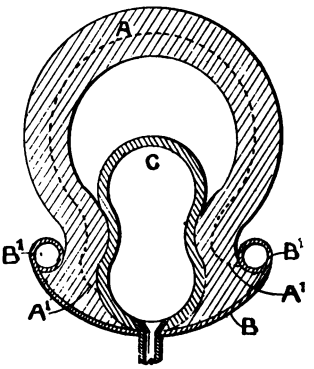

FIG. 91.—Shaw-Boothroyd-Sydenham Built-up, Wedge-action Pneumatic Tyre.

a tube C, located between them, and containing compressed air. The tube C can be inflated through the ordinary inflating tube, and a special inflating tube is provided to allow of air being forced into the space between the tube C and the outer casing A. The tyre is thus formed with two distinct air chambers, and should the outer casing A happen to become punctured, it will receive a certain amount of support from the inner tube C, and thus, it is said, not be rendered entirely useless.

Figs. 92 to 108 illustrate several forms of tyres adapted

to be secured upon the rims or felloes in the manner mentioned, some of which are amongst the best arrangements of this class in the market.

Fig. 92 shows one of the Palmer tyres, which is made by the Palmer Tyre Company Limited, under Bartlett's patent (No. 16,783[90]), already referred to. This tyre, which is an obvious improvement upon that of Bartlett, as originally constructed, has the reputation of being a very

FIG. 92.—Palmer Built-up, Wedge-action Pneumatic Tyre.

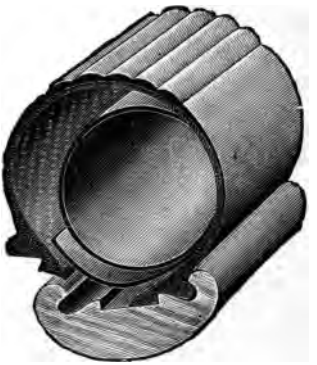

FIG. 93.—"G. & J." Built-up, Wedge-action Pneumatic Tyre.

fast tyre, and it certainly is amongst those easiest to detach. The Silvertown tyre is practically similar to the Palmer.

Figs. 93 and 94 illustrate what is known as the "G. and J." tyre. This tyre is made by the Gormully & Jeffery Manufacturing Company, and is shown in the drawings in two positions—viz., in Fig. 93 partially fixed in place upon the rim or felloe, and in Fig. 94 in process of removal therefrom. The rim or felloe in this instance is made of wood.

The following is the method of placing the tyre upon the rim :—Place the edge of the outer case having the wide flap in its place in the rim first. Next insert the valve, and lay the air tube on the top of the flap all the way round. The air should be all extracted from the tube before it is put in place. Push the remaining edge of the outer cover under the flap (which projects slightly over the rim), and firmly into its place in the rim.

A valve for use with the above, made by the same firm, is shown in Figs. 95, 96, and 97. It is of simple construction,

FIG. 94.—Gormully & Jeffery Built-up, Wedge-action Pneumatic Tyre.

and the different parts thereof are very readily "get-at-able." Practically it consists of two principal parts, viz., first, a hollow brass stem with a check valve, the office of which is to prevent the air from rushing out when the pump or inflator is removed, and before the cap can be screwed on; and secondly, of this cap itself, which serves to permanently imprison the air within the tyre. The complete valve is shown partly in vertical central section in Fig. 95, and the cap and packing in Figs. 96 and 97.

Several forms of wedge-action pneumatic tyres form the subject-matter of two patents taken out by J. W. Bowley, No. 9,210 of 1896, and No. 23,518 of 1895. Referring to the form of tyre illustrated in Fig. 98, which is that described in the first-mentioned patent, or that of the most recent date, each edge of the tyre cover has formed upon it an extensible core, and the rim or felloe of the wheel has inturned beaded edges, and is provided with an abutment. A separate elastic ring is located between each core and the side wall and inturned edge of the rim or felloe. The novel part of this invention is claimed to be the means for

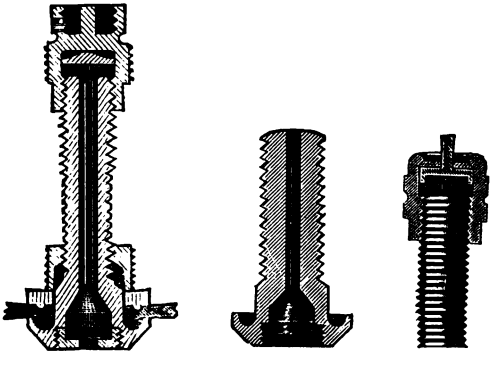

FIG. 95. FIG. 96. FIG. 97.

Gormully and Jeffery Pneumatic Valve.

detachably securing a pneumatic or the like tyre to a wheel rim, comprising a tyre or tyre cover, with cores at its edges, a wheel rim with a radially projecting abutment, and inturned edge flanges, extending circumferentially beyond the radius of the said abutment, and separate elastic rings, so combined and operating that upon the tyre being inflated the said elastic rings, actuated by the expanding base of the inflated tyre, are caused or permitted to roll or sink down the side walls of the wheel rim, and drive the cores therefrom into their positions against the abutment.

In Fig. 99, which illustrates a form of tyre described in the last-mentioned patent, or that of prior date,

A is the rim or felloe, B the inflatable tube, C the outer cover, D the elastic thickened or flaring edges of the said cover, which are seated between the flanges E and the side walls of the rim, and held in place by separate indiarubber or elastic rings or cushioning buffers F, so that, although the tyre is kept in position when deflated, the more it is inflated the tighter the attachment will be. The flanges G terminate with beaded edges to prevent cutting or chafing of the tyre. Fig. 99 shows a wedge-shaped solid india-rubber or other core at the two edges of the cover, so

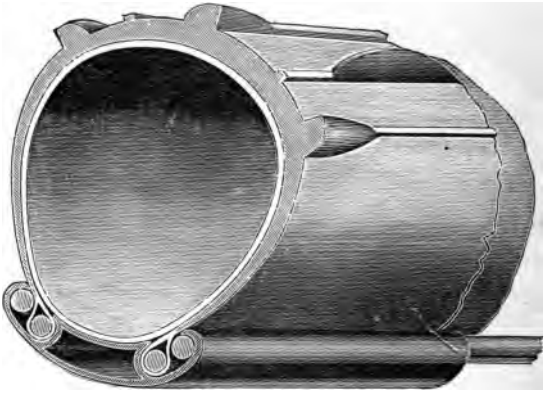

FIG. 98.—Bowley Built-up, Wedge-action Pneumatic Tyre.

formed that they normally project towards each other, and are turned in the process of attachment to the wheel rim into the position shown in the drawing.

To attach this type of tyre to the rim or felloe the cover, with the deflated tube B within it, is passed into the concave or channel bed of the wheel rim, the flaring or thickened edges or metallic T-pieces affixed to the edges of the cover being placed in their positions. The two elastic rings or cushioning buffers F are then sprung over the edges of the rim, and placed in the position shown. The novelty in the above is stated to be the tyre cover, with flaring or thickened elastic edges D, the wheel rim with

radially projecting flanges E, and inwardly projecting flanges G, extending circumferentially beyond the radius of the said flanges E, and the separate elastic rings F.

The following are examples of the form of tyres held in position by the wedging action due to inflation, but which are of what is known as the tubeless pattern—that is to say, a description of tyre that not only has no separate internal inflatable tube, but no complete tube at all until such time as the tyre is secured in place upon the rim, when it forms, in conjunction with the latter, an air-tight tube :—

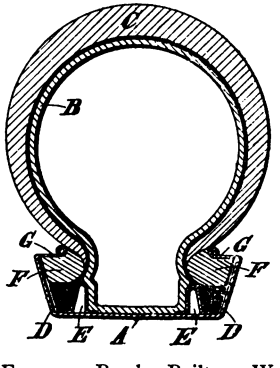

FIG. 99.—Bowley Built-up, Wedge-action Pneumatic Tyre.

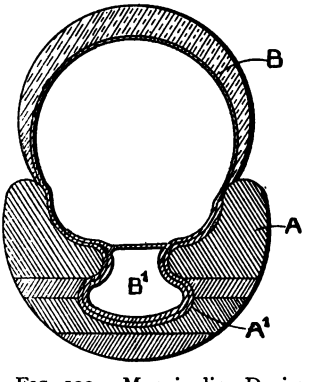

FIG. 100.—Mongiardino-Davies Tubeless, Wedge-action Pneumatic Tyre.

A tyre of this class, which appears to present a somewhat novel method of securing the attachment in this manner, has been patented by L. E. Mongiardino and Preston Davies, No. 13,848 of 1896. The wheel rim or felloe A is formed, as shown in Fig. 100, with either a central circumferential groove A^1, having a restricted opening, or with two or more of such grooves. The tyre B is constructed, when intended to be used upon a rim having one central groove, as shown in the drawing, with a pipe, channel, or passage B^1, of a size to pass within the groove A^1, and having one or more openings into the main chamber. Either overlapping flaps or an independent elastic ring may be employed to

form a temporary seal. The valve stem passes from the overlapping flaps through an aperture in the wheel rim, a washer being placed between the latter and the securing nut.

The tyre is placed upon the rim or felloe as follows :— The flaps are adjusted in position, and the pipe or channel B[1] is passed within the groove A[1] in the rim A. Upon proceeding to fill the main inflatable chamber through the pipe or channel B[1], the latter becomes first inflated, and expands within the groove A[1], so as to be firmly held therein,

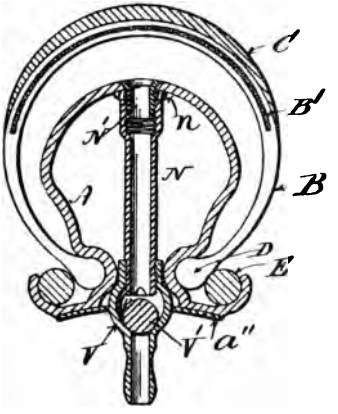

FIG. 101.

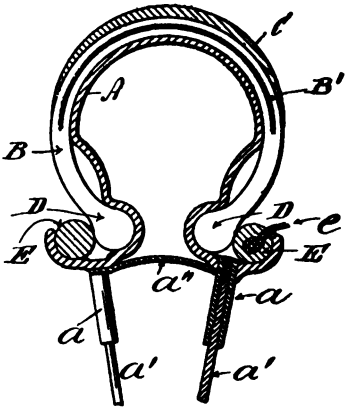

FIG. 102.

Lungren Tubeless, Wedge-action Pneumatic Tyre.

being unable to pass out when in that state through the narrow mouth or aperture. As inflation proceeds, the overlapping flaps are forced by the pressure of the air into close contact with each other and with the wheel rim, thus producing practically a single tube.

An American tyre of the tubeless type is that devised by C. M. Lungren, which forms the subject-matter of a U.S. patent, No. 482,182 of 1892. Several different modifications of his tyre are described, some of which are as follows :— In the one shown in Figs. 101 and 102, A is a tubular wheel rim, surrounded by a flexible envelope B, adapted to

be expanded by means of compressed air, as shown in Fig. 101. The wheel rim A is such a size and shape that it forms a support for the envelope B, when the latter is not inflated, as shown in Fig. 102, but when inflated, it stands clear of the said wheel rim as shown. Should, however, the envelope or tube B become punctured, and thus or otherwise lose its compressed air, it shrinks down upon the rim A, and still forms a serviceable tyre. B^1 is a web of canvas or other non-expansible material; C is a tread or reinforcement; D are enlarged edges or beads upon the tyre or envelope B; E are indiarubber retaining bands for keeping the said edges in place in channels formed at the edge of the rim or felloe A; *e* is a canvas tab for facilitating the removal of the tyre.

V is the valve for admitting of the introduction of air into the tyre or envelope B being effected. It consists of a globular valve-chamber, having a neck for the attachment of a charging-pump or inflator, and screwing into a nipple N, which latter screws upon another nipple N^1, having a flaring head, which is passed through the rim from the outside; the two nipples thus binding the wheel rim between them. *n* is an elastic washer for forming an air-tight joint. The valve end of the nipple N enters the valve-chamber, and is cut away or notched in one or more places to allow air to pass when the ball or spherical valve v^1 is pressed against it by the inrush of air from the inflator. The outwardly flaring shape of the rim admits of the nipples *a*, and spokes a^1, being placed as shown. a^2 is a strip of canvas for covering the base-opening of the rim, and preventing dirt from gaining access to the interior thereof.

In the arrangements shown in Fig. 103 the support for the tyre or envelope consists of a solid indiarubber or other tyre, mounted in a gutter-shaped portion of the tyre A. Fig. 104 shows the inner solid indiarubber tyre arranged in two ways, in both of which, however, the thickened or beaded edges D of the elastic tyre or envelope B are clipped between the outer edges of the rim and the inner indiarubber tyre. In the arrangement shown on the right hand side, the inner tyre is provided with side flaps extending round the thickened or beaded edges D, and locking ring or retaining strips E.

In Fig. 105, the inner tyre or support is dispensed with. The outer flexible envelope or tyre B is in this case provided with a web of canvas B^1 throughout, so as to render it non-expansible.

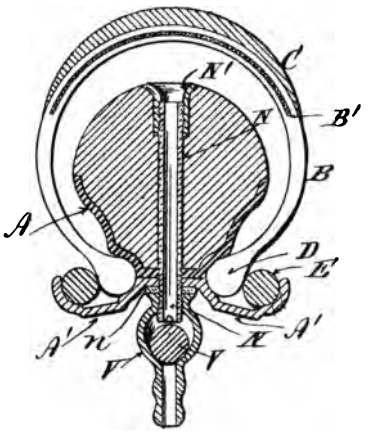

FIG. 103.—Lungren Tubeless, Wedge-action Pneumatic Tyre.

In the arrangement shown in Fig. 106 the outer cover, jacket, or flexible envelope C is intended to be secured to the lower flap J on each side by means of buttons and button-holes, laces, or the like, in the event of the collapse of the tyre through puncture. The elastic element otherwise necessary with the support may thus be dispensed with altogether.

Figs. 107 and 108 show the Fleuss pneumatic tyre, No.

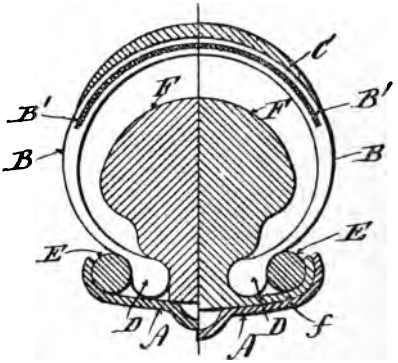

FIG. 104.

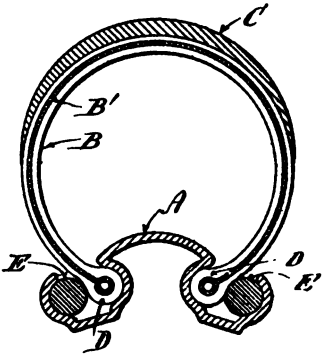

FIG. 105.

Lungren Tubeless, Wedge-action Pneumatic Tyre.

22,721 of 1895, in position upon the rim or felloe of the wheel, and detached therefrom. This tyre, which is also

of the so-called tubeless pattern, is so constructed as to be very easily removable from the rim or felloe, and replaceable in position thereon. The method of securing the tyre

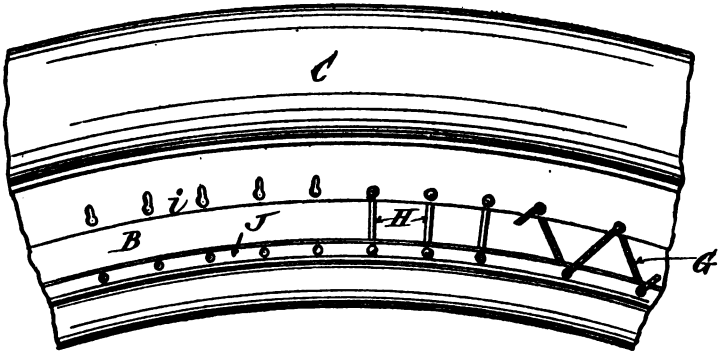

FIG. 106.—Lungren Tubeless, Wedge-action Pneumatic Tyre.

upon the rim will be readily understood from the illustrations. An air-tight joint is formed at the join by the flap shown.

A very great advantage possessed by tyres of this type is

FIG. 107.—Fleuss Tubeless, Wedge-action Pneumatic Tyre.

that they admit of punctures being repaired in the proper manner, viz., from the inside, and that too in less time than it would take to get at the air or internal inflatable tube of a tyre of the class having such inner tubes. It is obvious,

indeed, that even a very elementary repair made upon the inside, where the pressure of the air will constantly tend to force a patch against, and into the puncture or hole, must be more effective than one, no matter how carefully executed, on the exterior from which the pressure of the said air will constantly tend to blow the patch off. Tyres of this class, moreover, possess far greater resiliency than those having internal inflatable air tubes.

The inconveniences attending the puncture of pneumatic or air tyres, has not unnaturally led to the devising of numerous so-called self-sealing or self-healing tyres, and likewise to the construction of types built upon the principle

FIG. 108.—Fleuss Tubeless, Wedge-action Pneumatic Tyre.

of subdividing the space into a large number of separate compartments or cells, so that a puncture will only destroy the resiliency of one small part or section of the tyre, and thus admit of its being continued in use, for a time at any rate, without necessitating any immediate repair thereof. It is absolutely essential, however, to see that no dirt, grit, or other foreign body gets between the flap and the internal surface of the tyre, &c., as this will inevitably result in leakage and difficulty in starting the inflation with an ordinary inflator or air-pump.

Tyres constructed upon the first of these plans may have a loose inner tube—that is to say, one of larger diameter than the outer one by which it is kept in bounds or restrained;

the inner tube may be covered with small partially attached pieces overlapping each other, and breaking joint like slating, or various other arrangements may be used whereby if any object should pass through the two tyres, the puncture in the one will not upon the withdrawal of the said object coincide with that in the other, and consequently the leak will be stopped by the air pressure forcing an unperforated part of the inner tyre against it.

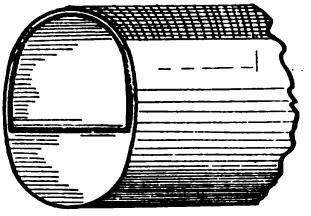

FIG. 109.
Self-healing Pneumatic Tyre.

Fig. 109 shows a self-healing air chamber of this type inflated. Fig. 110 illustrates a tyre fitted with one of the Puncture-Proof Company's speedifier bands having Lee's automatic attachment.

A favourite expedient also is the provision of a soft adhesive lining which closes up after puncture or perforation,

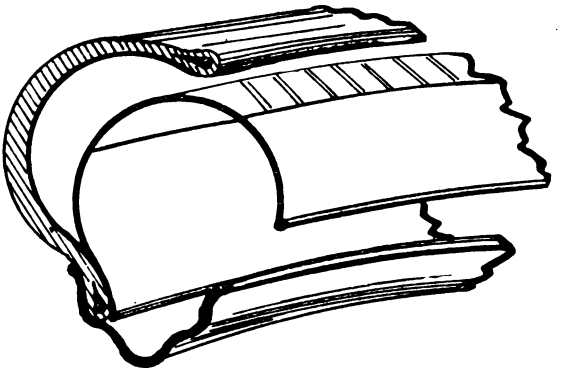

FIG. 110.—Puncture-Proof Company's Speedifier Band.

and a portion of which will become forced into the opening, and completely stop it up. The objections to these self-healing or self-sealing linings and tyres are, that many of them lose the property in question after a certain time, becoming useless, and only serving to reduce the resiliency of

the tyre; moreover, the outer or external indiarubber covering or sheath is, owing to the mode of manufacture, frequently softened and rendered useless.

Another arrangement patented by J. F. Palmer, in 1892, No. 10,766, is shown in Figs. 111 and 112. It consists in forming the air-tube from an indiarubber tube moulded to the shape shown in Fig. 111, the thickened portion B, being backed by a strip of inextensible canvas or like material, and the whole being preferably enclosed in a canvas casing. In Fig. 111, it will be seen that the thickened part B of the indiarubber tube is placed nearest the centre of the wheel, but to form the finished tyre, the tube must be inverted by a twisting operation, so that the said thick

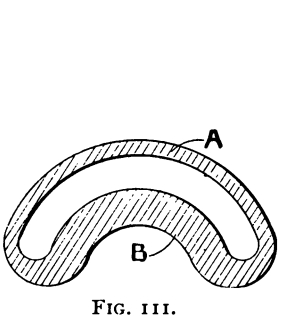

FIG. 111.

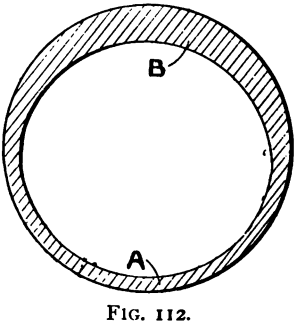

FIG. 112.

Palmer Puncture-Proof Pneumatic Tyre.

portion will be placed upon the outside, and the thin part A come next the rim or felloe of the wheel, as shown in Fig. 112. The inextensible canvas strip is formed by superposing two canvas strips, so that the fibres which run diagonally will lie in opposite directions.

The advantage claimed for this method of making the tyre is that the indiarubber becomes compressed by the action of turning the tyre, which fact, it is held, will tend to prevent an escape of the air should the tyre become perforated.

In another patent of the same inventor, No. 10,768, also of 1892, an improved air-tube is described, which is made, as shown in Fig. 113, from a strip of indiarubber A, moulded on a canvas strip B, to a U-shaped form and vulcanised, the

strip being subsequently inverted, so that the canvas will be placed on the outside, and the indiarubber will consequently become compressed. The edges of the strip are cemented together to form the complete tube.

In a modified arrangement of the above, the indiarubber strip is made with a diaphragm, which forms the inner part of the air-chamber. The edges of the said indiarubber strip are thickened so as to engage with a slot in the wheel rim. The edges of the outer casing will be held firmly together by the internal pressure, between the wheel rim or felloe and the indiarubber tyre.

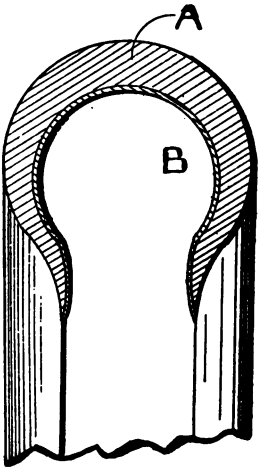

FIG. 113.—Palmer Puncture-Proof Air-tube.

Two other patents were taken out by the same inventor in 1893, containing descriptions of improved fabrics for tyres, viz., Nos. 11,820 and 4,926. In the latter inextensible threads are embedded, so as not to touch one another, in indiarubber, before vulcanisation; another

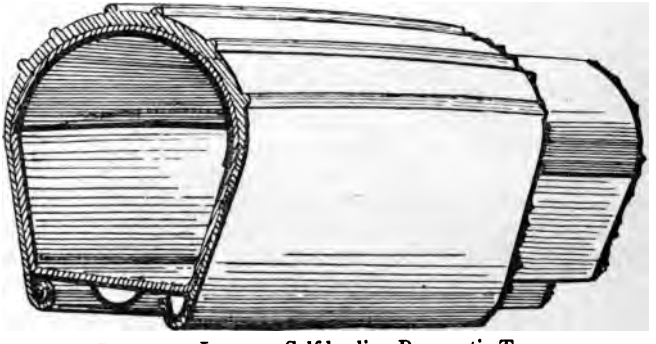

FIG. 114.—Lazerges Self-healing Pneumatic Tyre.

similar set of threads crossing the former at any angle being likewise, if desired, so embedded.

A French tyre of the so-called unpuncturable type has been invented by M. Larne, and another by M. Lazerges, which latter is shown in Fig. 114. Both are of that class wherein the material forming part of the tyre is so treated

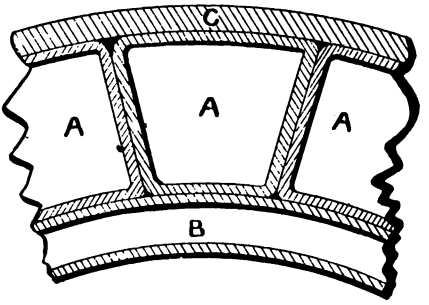

FIG. 115.—Stuart Unpuncturable Pneumatic Tyre.

by means of a suitable volatile substance, as to remain in a soft and partially unsolidified condition.

A pneumatic tyre having its internal space subdivided into a large number of cells or compartments, is shown in Figs. 115, 116, and 117. Fig. 115 is a vertical central

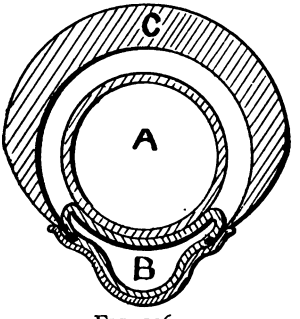

FIG. 116.

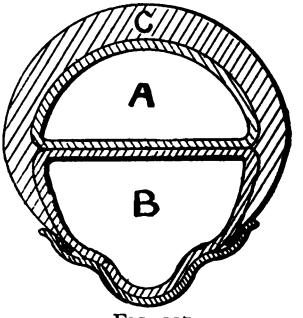

FIG. 117.

Stuart Unpuncturable Pneumatic Tyre.

longitudinal section through a portion of a tyre constructed upon this plan, partly inflated, Fig. 116 is a transverse section showing the tyre deflated, and Fig. 117 is a transverse section showing the tyre fully inflated. The arrangement is one of

great simplicity, and is applicable to any pneumatic tyre having an inner inflatable tube. It consists in the insertion of short segments A of flexible tubes, each of which forms a distinct air-cell or compartment, which are introduced between the ordinary pneumatic or inner inflatable tube B and the outer cover C. Upon the inflation of the pneumatic tube B in the usual manner, the cells A are forced against the outer jacket, and the extremities of the segments of tubes being pressed close together constitute air-tight walls, so that in the event of the outer cover C being punctured or perforated, as also the exterior skin of one of the cells A, the air will only escape from one, or at most two of the said cells. Even should a number of these cells become perforated, the tyre will not be rendered useless. A complete set of cells for a 28-inch wheel, with a 2-inch tyre, weighs under 2 ozs. This tyre, or rather safety addition for use in pneumatic tyres, is the invention of H. Akroyd Stuart.

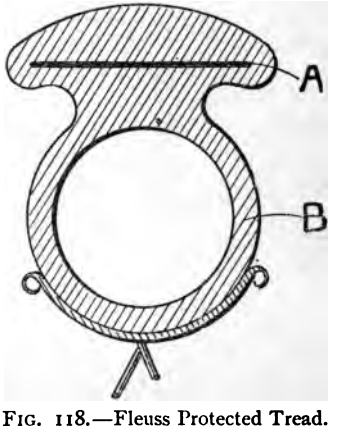

FIG. 118.—Fleuss Protected Tread.

An objection to this latter form of tyre, as also to such as have a packing or filling of balls wherein air is sealed or enclosed in the ordinary manner, is that under pressure they soon lose their air by imperceptible leakage through the pores of the indiarubber walls.

Fig. 118 illustrates a tyre with a protected tread for which a patent was taken out by H. A. Fleuss, in 1893, No. 12,309. The protection consists essentially in employing a hoop of thin tempered steel, as indicated at A, which must be of a breadth not less than the diameter of the air-tube B. This hoop A is embedded or enclosed in an indiarubber tread, and is secured to the air-tube by vulcanisation, being preferably coppered or otherwise plated, so as to enable the indiarubber to firmly adhere to it. Instead of

being enclosed or embedded, as shown, the hoop may be secured in place by a strip of vulcanised indiarubber fixed to the air-tube B by cement. Or when an outer covering is employed, the hoop may be embedded in this. The illustration shows the hoop as applied to a tyre of the solid wall type. The application of this metal hoop to the tread of a pneumatic tyre would evidently destroy the advantage, which is the primary reason for the use of tyres of that class.

The liability to puncture, and the great inconveniences attendant thereon, render a tyre of the pneumatic type that would be free or even partially free from such defect, a very desirable object. Unfortunately all tyres laying claim to possess this quality are also subject to very serious drawbacks. Those attendant upon most of the tyres having a lining of some partially solidified substance have been already mentioned. Many of those with so-called unpuncturable tubes are so in name only. The cellular tyres, an idea dating back to Thomson, 1845, are somewhat too complicated to be practically useful, and are besides even more wanting in resiliency than the two former types; whilst those wherein separate sealed spherical or other air-cells are introduced are objectionable in practice, as before mentioned, by reason of the air contained in the said cells leaking out through the pores of the indiarubber when placed under pressure.

This leakage through the pores of the indiarubber of course occurs slowly, almost imperceptibly indeed, but constantly, in all tyres, and its existence has been proved beyond doubt by an interesting experiment which consisted in placing dye stuff within the internal air tube of a pneumatic tyre. Upon dismounting the tyre after a short period of use, the tyre being to all outward appearance in a perfectly sound condition, the surfaces between the said inner air tube and the outer tube were found to be evenly stained by the dye, which had passed or worked its way through the pores of the indiarubber.

Some hints upon the care of tyres will be found in the chapter devoted to repairs. Meanwhile, it may be here remarked that it is most unwise to use racing tyres, or even light roadster tyres, for work upon country roads. In the first place, there will be the discomfort of feeling a constant dread of puncture, and the perpetual watchfulness entailed

to avoid, if possible, such a contingency ; and in the second, they will cause in the long run delay, as the time occupied in repairing the inevitable perforations that ensue from passing over flinty roads will be greater than that gained by their extra speed as compared with roadster tyres with compressed rubber strips solutioned upon the treads.

Although indiarubber is the most used material for the manufacture of pneumatic tyres, many other substances have been proposed, and some few tried. The success attendant upon the use of most of them has not been sufficient, however, to warrant their competing with the first-named material with any reasonable chance of success.

Amongst materials, other than indiarubber, used for pneumatic tyres leather forms the cheapest, the best, and the most durable that has been as yet tried. It is, however, unfortunately wanting in some of that pliability and elasticity which renders indiarubber so suitable for the purpose, and the main advantage derivable from the use of such tyres is thus to a certain extent lost. On the other hand, however, leather tyres are far cheaper and more lasting than those made of indiarubber, and, owing to the tread surface becoming speedily roughened by use, are almost completely free from the great tendency to side slip that renders indiarubber tyres so dangerous to use upon greasy or slippery surfaces.

A great objection to leather tyres as hitherto constructed has been that they were invariably formed in segments, consequently there were a number of joints in the circumference of each tyre, and each of these joints being either a butt joint, with a strip underneath, or a lap joint, not only was there a thickening of the tyre, and a loss of resiliency at these numerous points, but the liability to leakage was greatly increased, and the life of the tyre rendered of shorter duration. It was not possible, moreover, to so construct a tyre that it would be of uniform diameter throughout.

A form of pneumatic tyre has, however, been lately patented (No. 18,539 of 1893) by F. H. Walker, which has a leather outer cover with wedge fastening, and which seems to present a serviceable article, judging from one which the writer has lately examined after it had been used on a machine ridden for some hundreds of miles on general country roads, the wear upon the tyre from which work may be said to have

been practically *nil.* This tyre is shaped to the requisite form out of a long strip of leather by a special process, and consequently it has but one joint in its entire circumference.

Several types of valves for admitting of the inflation of the tyres have already been shown in connection with the latter. Amongst other valves said to give highly satisfactory results are the following;—The modern type of Dunlop valve, the Ross-Courtney, the Lucas, and the Bagot. The latter consists essentially of a disc valve packed with indiarubber, leather, or other material, and engaging with a knife edge upon the valve casing. A light spiral spring, located in a perforated cap or guard, maintains the said valve normally upon its knife edge seating, the said spring giving way and allowing the valve to open under the pressure of the inrush of air from the pump or inflator, and assisting the closing thereof. The end of the valve-spindle projects through the nozzle, and is screw-threaded, so that the valve can be brought tight up against its seating and locked in that position by means of a knob or cap. A suitable bridge piece is also provided to keep the tube off the rim or felloe at its point of connection therewith.

The inflation of pneumatic or air tyres is usually effected by means of hand inflators or air pumps, the construction and application of which is too well known to require description or illustration. It may here be observed, however, that the idea seemingly entertained by numbers of riders that a tyre is sufficiently inflated when the pressure is just enough to keep the rim or felloe of the wheel from coming in contact with the ground is erroneous. True, a somewhat more effective cushioning action is secured by using a slack tyre, but at the expense of its rapid destruction. A tyre should be kept inflated to an air pressure of from 25 to 35 lbs. per square inch, when riding, according to the weight of the rider, the greater the weight the higher of course will be the air pressure required.*

The inflator being a separate instrument, on that account not only adds to the weight to be carried, but is also liable to be frequently stolen from the cycle, and likewise to be left at home, and to be therefore absent when required on

* See also previous remarks on this subject, page 74.

an emergency. In consequence of this the ingenuity of inventors has been exercised to utilise one or more of the tubes composing the framework to form an inflator or inflators. The following are examples of devices of this kind:—

C. M. Raymond, No. 20,300 of 1892, forms a pump or inflator for pneumatic tyres by fitting a piston to the saddle supporting stem, arranged to work within the rear vertical stay which forms the pump cylinder. For riding the saddle is fixed by means of a special bush and bracket piece.

E. D. Loane, No. 18,276 of 1892, forms an air pump or tyre inflator in the saddle support, and in the steering fork stem, or in other parts of the frame.

In these arrangements the pumps or inflators so formed are connected up with the tyre valves when required by means of lengths of flexible tubing.

THE STEERING.

The mechanism comprised under this head consists, firstly, in the means adopted for mounting the steering head to admit of this latter part, as also the fork and steering wheel connected therewith, being turned or rotated for steering purposes; secondly, in the handle-bar or apparatus for enabling the said turning or rotating of the steering head, fork, and steering wheel to be affected, and for controlling the said wheel; and thirdly, in the fork for carrying the steering wheel.

Formerly the steering of tricycles entailed the use of racks and pinions, levers and connecting rods, and other gear—in some instances mechanisms consisting of more or less complicated arrangements of cams and springs being added to counteract the extreme sensitiveness of these steering devices. In a modern tricycle with front-steering wheel, however, such as either of those previously illustrated, the steering in no way differs from that of a safety bicycle or dicycle.

STEERING HEADS.—Figs. 119 to 124 illustrate three forms of modern steering heads. That shown in Figs. 119 and

120 is a steering or ball-head adjustment by Rudge-Whitworth Limited. The external appearance of the head is shown in the elevation (Fig. 119), and the internal arrangement of the parts will be clearly understood from the enlarged sectional view (Fig. 120). Referring to this latter view, A is the handle-bar stem, B is the adjustment cap, C is the lamp bracket, D is the head adjuster, E, E are the balls or spheres, F is the top or upper lug of the frame, G is the head tube of the frame, K is the locking pad, L is

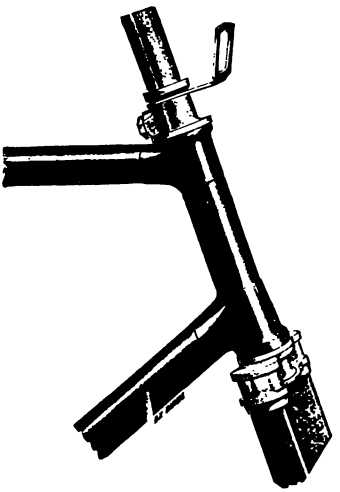

FIG. 119.—Rudge-Whitworth Steering or Ball-head Adjustment.

the locking pin, and M is the steering fork or fork stem. The arrangement of the mechanism is sufficiently evident from the drawing without further explanation.

Fig. 121 is a vertical section illustrating the steering or ball-head adjustment fitted to the machines built by Humber & Co. Limited. The arrangement of the parts of this head will also be easily understood from the drawing. A is the steering collar; B is the adjustment cap or collar. To effect the adjustment of the steering, the bolt which passes through the lugs on the steering collar, and clamps it in position,

must be first removed or slackened, and the adjustment cap or collar B then screwed down until all slackness is taken out of the head. After which the bolt of the steering collar should be again tightened up, and the adjustment will be complete. The adjustment cap or collar B may be tightened or screwed down by means of a peg, or pin-spanner, or wrench. The Humber steering or head lock,

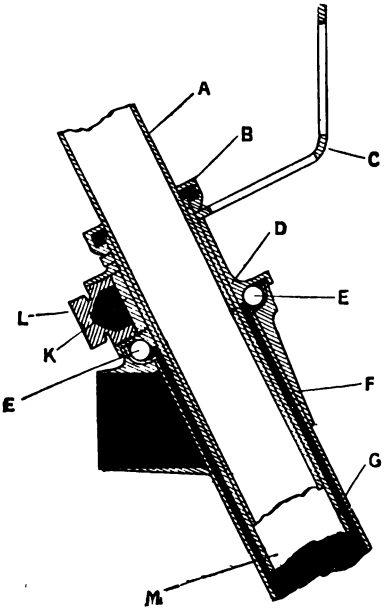

FIG. 120.—Rudge-Whitworth Ball Steering Head.

which forms the subject-matter of letters patent, No. 3,618 of 1895, has been already briefly described on pages 28, 29.

The Birmingham Small Arms Company also fit their steering head with a special steering or head lock. It consists of a strap round the fork head, to one end of which strap is jointed a pin passing through a hole in the other end of the said strap, and extending through a hole in the head. This projecting end is screw threaded, and a thumb-nut thereon

enables the strap to be tightened and the parts to be locked in position when desired.

Fig. 122 is a perspective view, showing the Singer & Co.

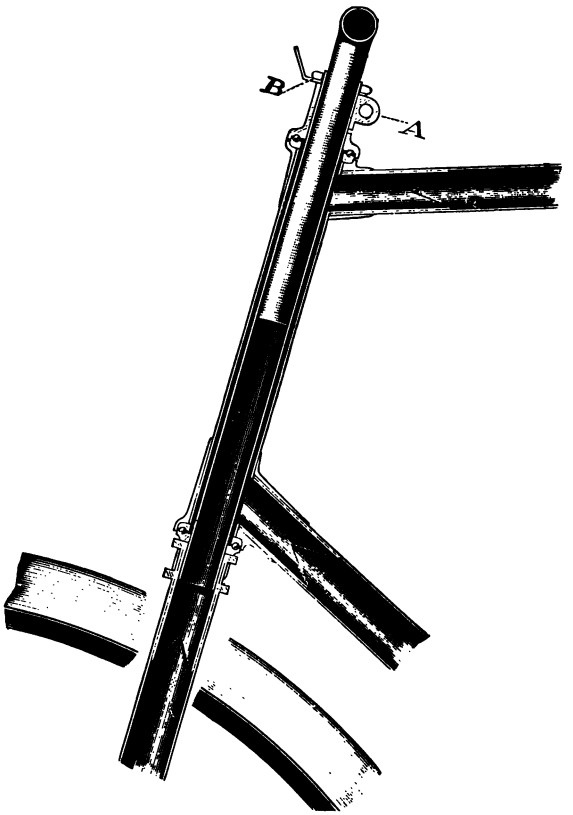

FIG. 121.—Humber Ball Steering Head.

Limited ball steering, and steering-lock. The first of these is said to afford a firm yet perfectly free steering for safeties, and has been used by the makers since 1887, during which

FIG. 122.—Singer Ball Steering Head, and Steering-Lock.

time it has given universal satisfaction. The latter arrangement was introduced about a year later, and consists, as will be seen from the drawing, simply of a catch or bolt, which by one half-turn of the short lever (shown on the right hand side) in one direction can be caused to engage

FIG. 123.
Perry Ball Steering Head.

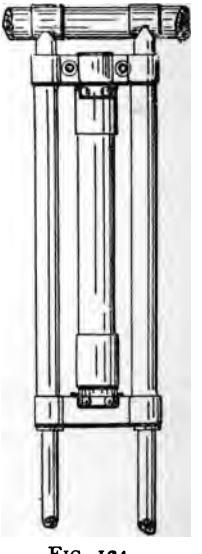

FIG. 124.
Triple Steering Head.

with projections upon the fork stem, as shown in the drawing, and thus to firmly fix the steering, so that the handle-bar cannot swerve, and by a similar half-turn in the obverse direction to instantly unlock and set free the steering.

Fig. 123 illustrates one of the several patterns of steering

heads made by Perry & Co. Limited. This head, which is intended for a light roadster machine, has a 1-inch upper socket and a $1\frac{1}{8}$-inch lower socket. The balls are enclosed in removable cones of tempered steel.

A simple type of combination steering and machine lock is also made by the Coventry Machinists' Company Limited, and both special ball steering heads and locks have been also designed by numerous others.

Fig. 124 shows a triple head made by the Referee Cycle Company Limited, which is designed to strengthen this important part. As will be seen from the drawing, there are two steering tubes. The handle-bar has thus two stems, and is held in place by two screws, thereby securing practically immunity from accident through breakage.

A duplex steering head is made by the Coventry Machinists' Company Limited.

HANDLE-BARS.—The second part of the steering mechanism, or that for controlling the steering wheel, consists as before mentioned of the handle-bar. These are constructed with levers curved into a great variety of forms and positions or angles, and of different lengths, and are also made so as to be adjustable to any desired angle to meet the requirements of different riders. The handle-bar comprises two parts, viz., the levers and the handles. The material most generally employed for the bars or levers is steel, and nickel steel (5 per cent. of nickel) is the best for the purpose. Wood is, however, also used, as in O'Brien's patent bent-wood adjustable handle-bar, which is twisted in a special manner claimed to impart great toughness, resiliency, and elasticity, and to absorb vibration more effectually than the ordinary wood handle-bar.

A most important point to be attended to is the height and angle of the handle-bar, which should be such as to admit of the rider sitting perfectly upright with his arms straight. This is the limit of height to which the handle-bar should be raised, as if the handles be placed any higher, the arms will have to be bent, which means a loss of power, and a position nearly if not quite as unsightly as the stooping, bow-backed attitude of the scorcher. The bending of the tubes to form the curve of the handle-bars is, or should

be, effected cold by means of special tube bending apparatus.*

Figs. 125 to 132 illustrate the standard patterns of handle-bars made by Humber & Co. Limited.

Fig. 125 shows what is known as a flat roadster handle-bar, the width of which is 21 inches from the centre of one handle to the centre of the other. The bar itself is placed at right angles to the stem, but is inclined at such an angle

FIG. 125.
Flat Roadster Handle-Bar.

FIG. 126.
Flat Road Racer Handle-Bar.

with the ground, that the tips of the handles are situated about three inches lower than the highest part of the bar. This is done in order to give the most comfortable position to the hands.

Fig. 126 is known as a flat road-racer handle-bar. This pattern differs from the first described in that, it is not brought quite so far back, and is, moreover, only 19 inches across. This pattern is suitable for riders who require a

FIG. 127.
Semi-Drop Handle-Bar.

FIG. 128.
Scorcher Drop Handle-Bar.

very narrow flat handle-bar, and is especially suitable for road and path racing safeties.

Fig. 127 illustrates a semi-drop pattern suitable for use on roadster machines by riders who prefer a slightly dropped or lowered handle-bar. This handle-bar is 21 inches in width, and has a drop of 1½ inches in addition to

* See chapters on Manufacture or Construction and Repair of Cycles for further particulars on this head.

the inclination with the horizon mentioned with reference to Fig. 125, which inclination is common to all handle-bars.

Fig. 128 is a scorcher drop handle-bar, which type is used upon road-racer safeties, road-racer tricycles, and road-racer tandems. This handle-bar has a drop of $3\frac{1}{2}$ inches, and is 19 inches in width.

Fig. 129 is a path-racer drop handle-bar, for use solely

FIG. 129.
Path Racer Drop Handle-Bar.

FIG. 130.
Forward Racer Handle-Bar.

upon path-racing machines both bicycles and tricycles. The drop of this handle-bar is 5 inches, and the width of it is 19 inches.

Fig. 130 depicts another racing handle-bar known as the forward racer handle-bar. In this pattern the bar is curved so as to bring the handles into as advanced or forward a position as possible. It is 19 inches in width, has a drop

FIG. 131.
Raised Pattern Handle-Bar.

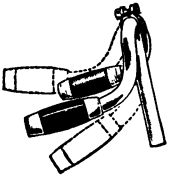

FIG. 132.
Patent Adjustable or Swivelling Handle-Bar.

of 5 inches, and the distance from the forepart of the stem to the furthest forward point in the bend is 3 inches.

Fig. 131 is a raised pattern handle-bar, the tube being so curved that the handles are, as shown, raised upwards instead of dropped. This type of handle-bar is suitable for such riders as require to have them raised very high; and, by the upward curvature of the tube, this end is effected

without having an abnormally long portion of the stem projecting above the socket. By this means not only is the unsightliness consequent upon the use of a level handle-bar with an extra long stem avoided, but the arrangement affords far greater strength. This handle-bar is usually made 21 inches across, but can be also constructed 19 inches across when required.

Fig. 132 shows the Humber adjustable or swivel handle-bar, which forms the subject-matter of a patent, No. 14,768 of 1895. This handle-bar is more especially intended for the rear portion of tandem and triplet safeties. It is so designed that the bar itself can be tilted or adjusted to any angle desired relatively to the pillar or stem. Four different positions can be obtained, and in each of these positions the handles can be adjusted to any desired angle. It is evident, therefore, that the adjustments of this handle-bar will admit of its being arranged to suit almost any rider. This type of handle-bar can be fitted to any standard safety bicycle when no brake is required; its width across is 19 inches. The "Columbia" handle-bar is reversible. The new Palmer handle-bar is collapsible. Other adjustable handle-bars are those of the Hollis, and of W. H. Castle, patent No. 18,466 of 1896.

Attempts have been made from time to time to devise an efficient spring handle-bar, or to otherwise provide for eliminating the objectionable jarring experienced with practically rigid handle-bars when riding over rough roads or surfaces at any speed. About the first to make any attempts at improvement in this direction was John Cox, who describes in his patent, No. 834 of 1869, elastic handles for cycles, formed partly of flat steel and partly of tempered iron. He likewise provided for reducing jarring or vibration by the use of indiarubber. Air cushions have been also used. None of these anti-vibration handle-bars have, however, stood the test of actual constant use, and never came into favour with riders.

The handles or portions of the bar to be gripped by the hands are made of a very great variety of substances, and fixed in place in a large number of ways, the most unsatisfactory of which latter is any description of cement. Amongst the substances that have been used are zolonite,

celluloid, indiarubber, vulcanite, horn, cork, felt, &c.; and numerous pneumatic, ventilated, anti-vibrating or cushioning, and other special handles have also been designed.

Fig. 133 shows in longitudinal central section an anti-vibrating handle invented by Lucas. A is a steel tang screw-threaded, as shown at B, so as to screw into the handle-bar, or it may be brazed into the latter. C, C are corrugated cones and washers made of soft indiarubber,

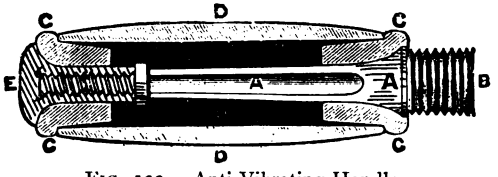

FIG. 133.—Anti-Vibrating Handle.

upon which cones is supported a horn handle or grip D. E is a nut by means of which the indiarubber cones C, and the handle or grip D, are fixed upon the tang A. It will be readily seen that the handle is completely insulated from vibration owing to the manner wherein it is mounted on the soft indiarubber cones, which latter are rendered still more yielding by being corrugated. The horn grip or handle

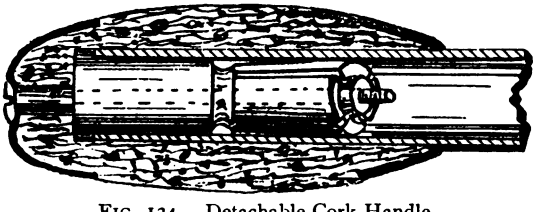

FIG. 134.—Detachable Cork Handle.

is retained in this cushion handle, which is an advantage as it is one of the best, if not the best of the materials used for the purpose, and affords a firm grip, which in this case is combined with great elasticity.

Fig. 134 illustrates a cork handle which, it will be seen, is readily detachable. It is secured in position by a hollow split piece which fits inside the end of the handle-bar, and is expanded by means of a conical or taper plug drawn into

the bore of the split taper piece by a screw which can be operated from the exterior of the handle. To remove the handle it is only necessary to slacken this screw by means of an ordinary screw-driver.

The Tyton handle has tubular screw ends, and can be firmly fixed to the lever or handle-bar end without the aid of cement.

Felt handles are claimed to be very light and strong, and not to become sticky in use, and also to afford so perfect a grip that any slip becomes a matter of impossibility.

FORKS.—The severe strains to which the steering or front wheel forks are subjected when the cycle is in use has been already alluded to. These strains are at a maximum when turning corners at a high velocity, and considering their severity, the only wonder is that more accidents do not happen, as the margin of safety is in most cases very slight indeed.

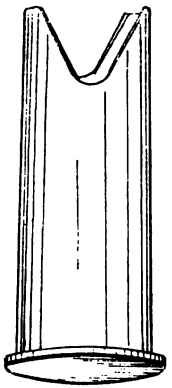

FIG. 135.
Fork Strengthener.

As has been already mentioned, the forks are as a rule made from tube of an oval form in transverse section, so as to better withstand the strains to which they are subjected when in use.

A method of constructing forks for cycles from a single length of tubing has been patented by C. Brown, No. 7,446 of 1894. The fork is constructed by first flattening a suitable length of tube at its ends, and forming therein holes to receive the wheel spindle. It is then shaped to the required section, and the two ends are bent to form legs. A boss is also formed on the crown to receive the steering stem.

In the forks as usually constructed the upper ends of the tubes forming the blades are frequently left open, and are consequently not only unsightly, but form receptacles for dirt, water, &c. A handy little stopper or cap for closing these openings can be made by cutting two pieces of metal of the shape of the tubes, and soldering to them thin strips of metal, which can be sprung together and inserted into the said tube, wherein they will expand and hold the cap in position

A more substantial device for closing the open ends of a fork is that patented by F. & E. Warwick, No. 8,407 of 1894. This contrivance consists of a close-ended hollow plug, formed of a liner with tenons, which is first placed in the fork end, and upon which a plate, with holes to receive the said tenons, is fitted, and the latter riveted over so as to hold it firmly in place. The plug is permanently fixed in position by brazing it into the fork end.

Fig. 135 illustrates a form of fork strengthener very frequently employed.

Considering the frequent fracture and buckling to which single forks are liable when in use, it is not surprising that a considerable number of so-called unbreakable forks have been designed with the view of precluding the possibility of such accidents.

One of these special or so-called unbreakable forks is shown in Figs. 136 and 137. It is made by a French firm — E. Verdot et Cie. — and

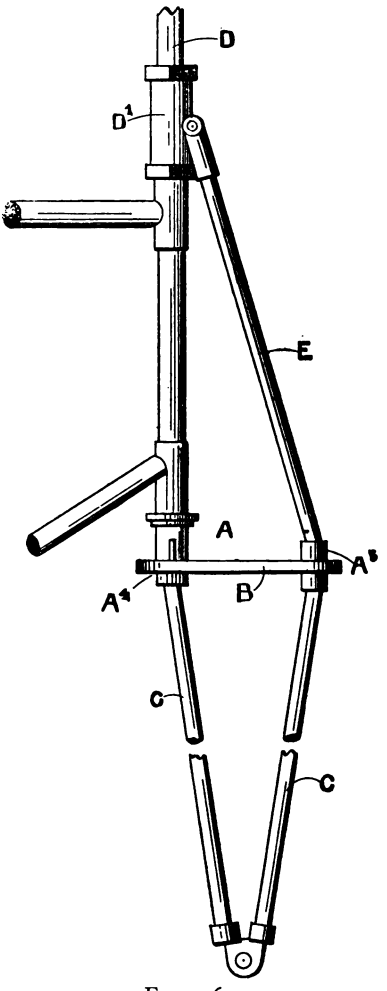

FIG. 136.
Unbreakable Fork (Side View).

a British patent has also been obtained by the inventor, E. P. Verdot, for the device, viz., No. 22,127 of 1894. As will be seen from the illustration, the fork is composed of double members of slighter tubes than are ordinarily employed in single forks, and braced together where necessary. The lower part practically consists of two forks, the ends meeting at the axle, and there are two stays running from the top of the outer fork to the top of the steering head. Whilst affording a large increase of strength as compared with the ordinary single fork, it is stated that this double type of fork can be made quite as light as the former.

The construction of the Verdot fork will be more clearly understood by referring to the letters upon the drawing.

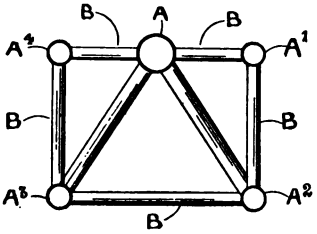

FIG. 137.—Unbreakable Fork. (Horizontal Section.)

The crown of the fork is formed of a number of sockets A^1, A^2, A^3, A^4, connected together by ribs B. Two pairs of rods C are secured in the lower portions of the sockets A^1, A^2, and A^3, A^4 (the latter of which pairs is shown in Fig. 136), to form the fork sides. The steering stem D is secured in the socket A, and a pair of stays E (one of which only is shown in Fig. 136), connected to the said steering stem D, as indicated at D^1, are secured in the upper portions of the sockets A^2, A^3. The stays E are in some cases divided and made adjustable in length by right- and left-handed sleeve nuts; and they are also sometimes connected to the fork crown and steering stem by means of bolts passing through projecting ears or lugs. Either two stays, as shown, or a single stay, or any other suitable number, may be employed.

The principle upon which the above-described fork is constructed is evidently the true and proper one for the rest of the framework. Far greater strength and rigidity, with equal lightness, could be attained; and, moreover, the unwieldy and awkward joints now required with the single tubes might be considerably modified by the use of compound members.

Driving Gear.

In the modern type of bicycle or dicycle and tricycle the power is applied to the pedal axle, and is thence communicated to the driving axle in two principal ways—viz., by chain driving gear, and by gear wheels. Many other plans

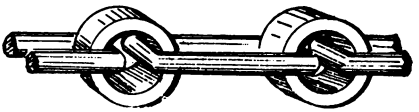

Fig. 138.—Morgan Driving or Pitch Chain.

have been proposed and tried, and some are even used to a certain extent, as, for instance, bands and eccentrics, or pulleys or drums, friction wheels, cranks and coupling rods, bevel or mitre gearing, cam gearing, &c. To impart the

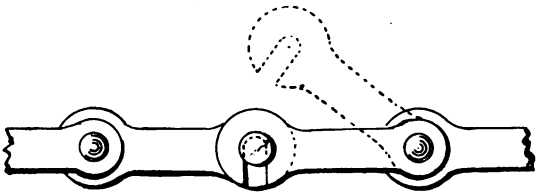

Fig. 139.—Starley Detachable Link Pitch Chain.

requisite rotary motion to the driving axle, cranks and pedals are universally employed.

Chain Driving Gear.—No doubt the manufacturers of cycles have brought chain driving gear to a considerable

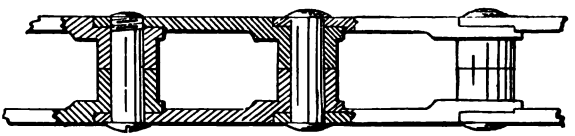

Fig. 140.—Abingdon Single Link Pitch Chain.

degree of perfection, and the chain or sprocket wheels and pitch chains forming the driving gear upon a high grade cycle is a very fine piece of mechanism, and one which works with comparatively little friction, not exceeding in the best

forms of chain gear 1 per cent. and at most 3 per cent. of the total friction of the machine. Many different patterns of pitch chains have been designed from time to time, amongst which may be mentioned those of Morgan, Starley, Abingdon, Reynolds, Brampton, Appleby, Perry, Dunlop, Renold, and Eadie.

FIG. 141.—Perry-Humber Pattern Pitch Chain.

Morgan's patent, No. 1,352 of 1883, contains descriptions and illustrations of a number of pitch chains. Fig. 138 shows the type of Morgan chain in extensive use in 1885. As will be seen from the illustration, it consisted of alternate rectangular links, formed of round steel wire, and hollow steel

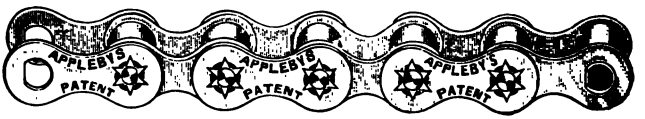

FIG. 142.—Appleby-Humber Twin Roller Pitch Chain.

rollers. Starley's detachable link chain is illustrated in Fig. 139, the method of detaching being clearly shown in dotted lines. Fig. 140 is a plan, partly in section, showing one form of Abingdon chain, which has been for a considerable time a prime favourite. Brampton's is a long link roller

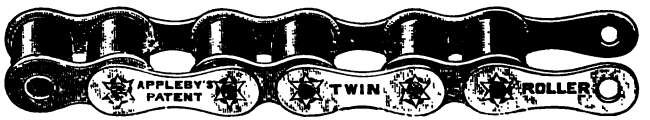

FIG. 143.—Appleby-Osmond Dwarf Roller Pitch Chain.

chain. The ordinary block chain (see Fig. 163) is too well known to require description. There are many varieties of the dumbbell block chain, which is a type which, all things considered, has been found to be very suitable for general

work. Fig. 141 illustrates Perry's Humber pattern chain, which is fitted with patent hardened pen-steel bushes. Figs. 142 and 143 show two recent patterns of Appleby chains, which are very highly spoken of as affording first-class results as regards durability and engendering a minimum of friction in use. These chains are known as the Appleby-Humber "Twin" Roller Chain, and the Appleby-Osmond "Dwarf" Roller Chain. Their construction is sufficiently apparent from the illustrations. The Eadie pitch chain is made in two principal patterns, the one a detachable link chain with locking plates, and the other a roller chain.

Figs. 144 to 165 illustrate various arrangements of the different parts of the ordinary chain driving gear.

Figs. 144 to 153 illustrate various component parts of driving gear, showing some examples of the numerous different types made by Perry & Co. Limited. Figs. 144 and 145 are two views of a crank driving gear fitted with their patent detachable sprocket or chain wheel, which is screwed against a collar connected with one of the crank arms, and secured in position by a locking ring screwed upon a reduced part extending beyond the boss of the said wheel. Fig. 146 is a bridge piece for use with the above bottom bracket. Fig. 147 shows the rear or driving-wheel hub and sprocket or chain wheel, the latter being shown more clearly detached in Fig. 148. Figs. 149 and 150 are the fork ends and chain adjustment. Fig. 151 is a tricycle bottom bracket. And Figs. 152 and 153 are two views showing Humber patterns of sprocket wheels.

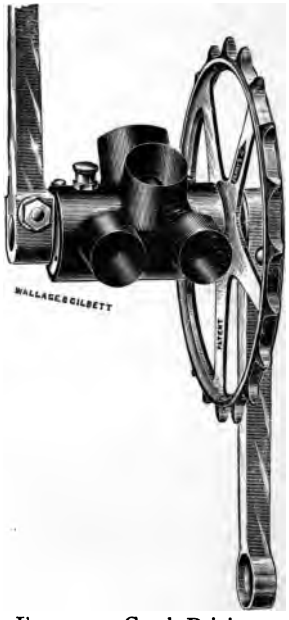

FIG. 144.—Crank Driving Gear and Bottom Bracket.

A distinctive feature of the Spaulding bicycle is that the

rear forks and the back stays are constructed in one continuous piece, thereby greatly strengthening the points of attachment to the axle of the driven wheel, and the chain adjustment.

Fig. 154 is a vertical central section, showing the Rudge-

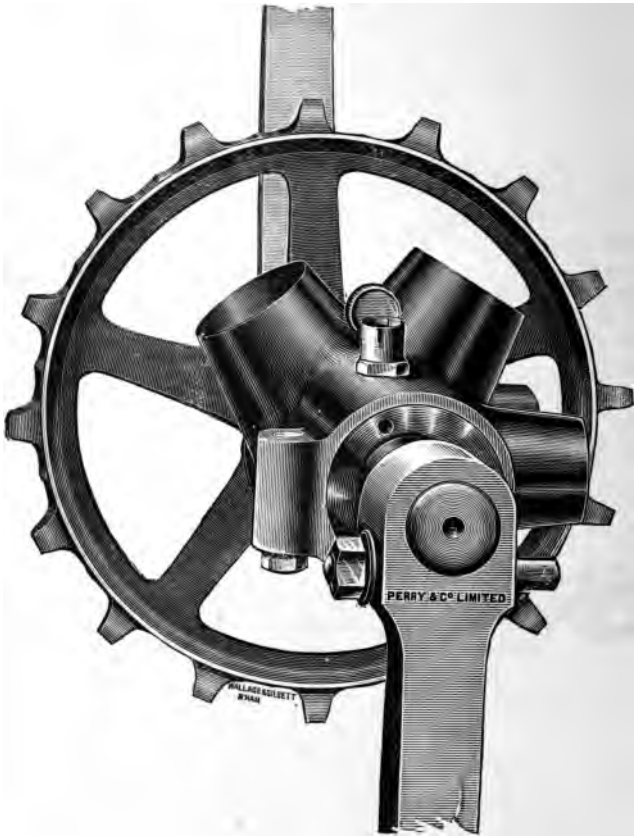

FIG. 145.—Crank Driving Gear and Bottom Bracket.

Whitworth crank bracket, and Figs. 155 and 156 are perspective views illustrating respectively the interchangeable gear, and the rear chain adjustment made by the same firm.

Referring to Fig. 154, A, A^1 indicate the outer cups with felt dust protectors; B, B^1, the inner cups; C, C^1, the adjustment slots; D, the body of the bracket; E, E, the balls; F, F^1, the crank keys; G, one of the nuts for the latter; H, H, the cranks; and K, K^1, the oiling channels. The arrangement of the bracket will be plain from the above, and it will be seen that it is both completely dust proof, being fitted with a further safeguard against the entry of dust in the shape of a felt protector at each end of the bearing, and that it is likewise oil-containing. The adjustment is exceedingly simple and easily effected. The cranks are of a new pattern $6\frac{1}{4}$ ins. throw, and very readily detachable. Their design renders them of great strength. The width of the tread is $4\frac{7}{8}$ inches.

FIG. 146.
Bottom Bracket
Bridge Piece.

The interchangeable gear, which is more clearly shown in Fig. 155, admits, by the removal of the chain ring, and the substitution of another of any desired size, of the gearing of

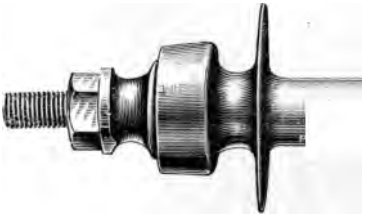

FIG. 147.—Driving Wheel Hub and Sprocket.

the machine being readily altered to suit any particular circumstances.

The rear chain adjustment will be also readily understood from the illustration (Fig. 156).

Fig. 157 shows the Singer detachable crank bearing,

which is so constructed that it can be removed from the frame complete, after taking off one of the cranks and the lubricator. The width of the tread varies from $4\frac{1}{8}$ inches up to $5\frac{1}{16}$ inches. This bearing is also perfectly dust-proof and oil-retaining, and it is very easy to adjust.

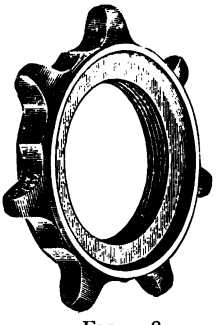

FIG. 148.
Driving Wheel Sprocket or Chain Wheel.

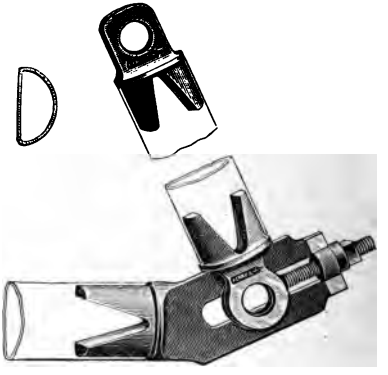

FIG. 149.
Fork Ends and Chain Adjustment.

Figs. 158 and 159 are a sectional plan and side elevation illustrating the Humber crank bracket adjustment. A is a locking or set screw by means of which the adjustable cone B can be fixed in position. C is the fixed cone, the removal

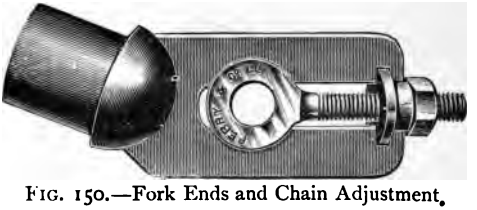

FIG. 150.—Fork Ends and Chain Adjustment.

of which is only required when repairs become necessary. D is one of the cranks, the one on the other side is shown partly broken off. The adjustment is effected in the following manner:—The set screw A having been first slackened, the loose cone B can be tightened by screwing it up into

the bearing until all side play or shake disappears, holes being provided in the exterior face of the said cone (as shown more clearly in Fig. 159, wherein the crank is removed), to admit of its manipulation by means of a peg or

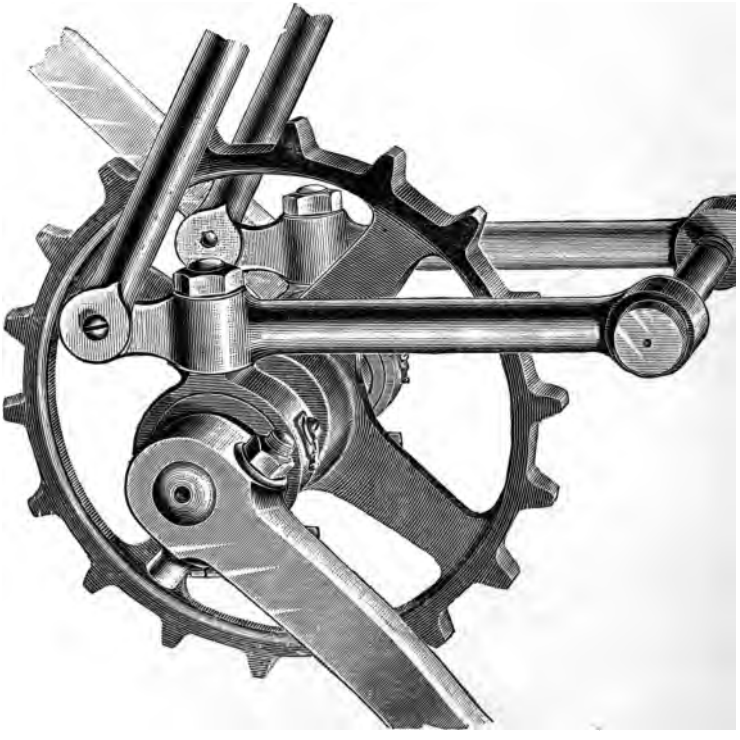

FIG. 151.—Tricycle Crank or Bottom Bracket.

pin wrench or spanner. When the cone has been properly adjusted, the locking or set screw A should be again tightened.

The crank D and gear or sprocket wheel are formed so as to be very readily detachable. This arrangement,

FIG. 152.—Humber Pattern Sprocket or Chain Wheel.

FIG 153. Humber Pattern Sprocket or Chain Wheel.

which is shown more clearly in the sectional view, Fig. 158, is both registered as a design, and also forms the subject-matter of a patent, No. 4,389 of 1895. The chain or sprocket wheel is screwed upon the boss of the crank, and is locked by a wedge piece and screw, a mode of fastening

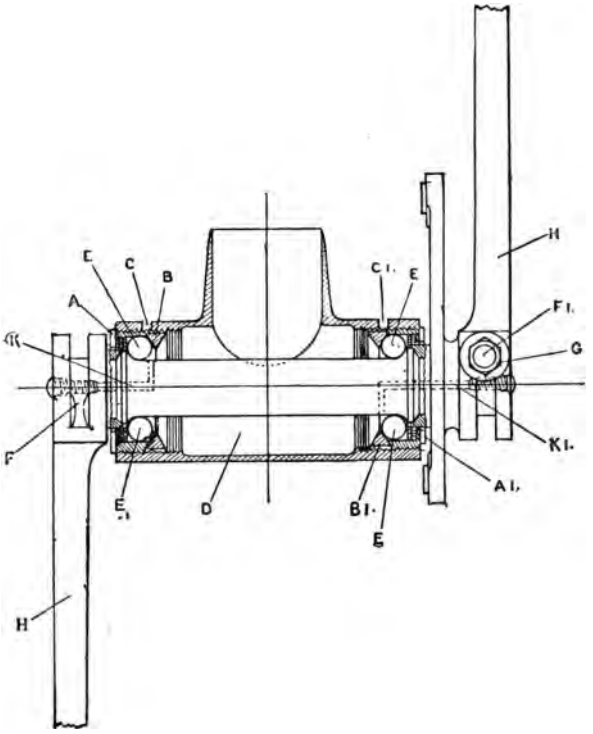

FIG. 154. – Rudge-Whitworth Crank Bracket.

which is found to be very reliable, and which, moreover, admits of a perfect alignment of the bracket chain wheel with the hub ring, the former being capable of being adjusted from $\frac{1}{24}$ of an inch either to the right or left. The right hand ball race, moreover, can by this arrangement be

FIG. 155.—Rudge-Whitworth Interchangeable Gear.

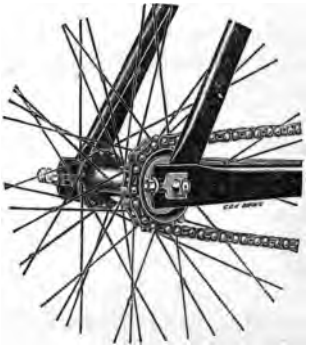

FIG. 156.—Rudge-Whitworth Rear Chain Adjustment.

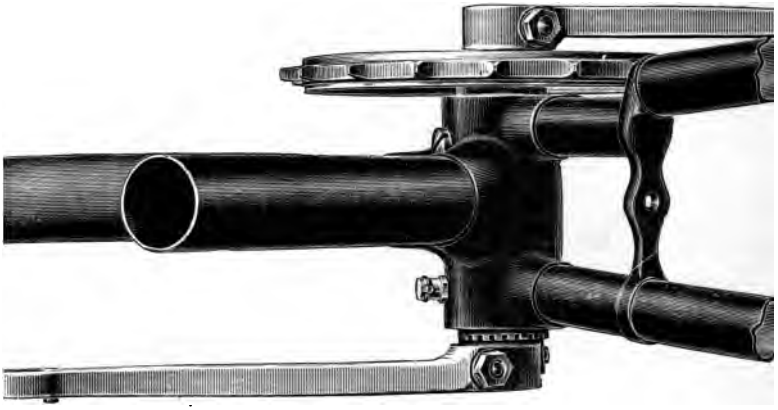

FIG. 157.—Singer Detachable Crank Bearing (Plan).

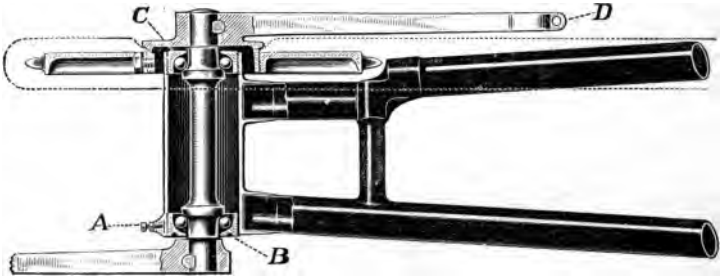

FIG. 158.—Humber Crank or Bottom Bracket (Sectional Plan).

FIG. 159.—Humber Crank or Bottom Bracket (Side View).

extended (as shown in Fig. 158), under and directly in line with the driving or pitch chain, thus relieving the crank

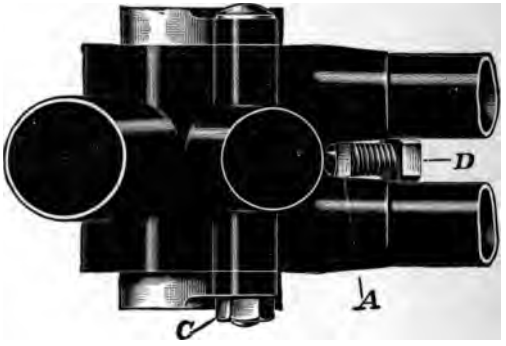

FIG. 160.—Humber Tandem or Triplet Swing Adjusting Bottom Bracket (Plan).

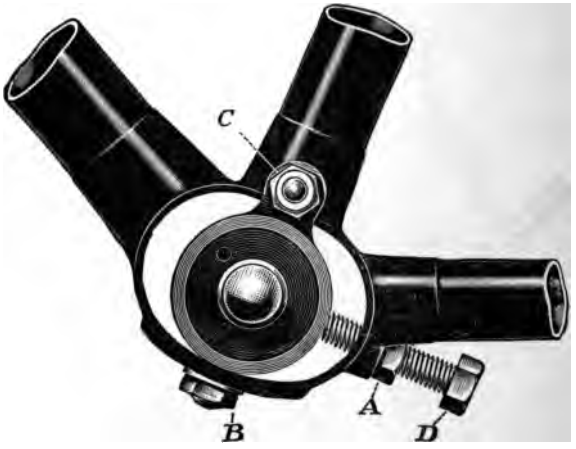

FIG. 161.—Humber Tandem or Triplet Swing Adjusting Bottom Bracket (Side View).

axle of all twisting strain, and the hub ring being as shown directly over its ball race, the pull of the pitch chain, it will

be seen, is immediately over the bearings at both points. The method of removing the gear wheel, to alter the gear or for other purposes, in shown in Fig. 164. This device is found to be superior to that wherein the chain wheel is screwed on to the boss of the crank by a right-handed screw-thread, and is secured thereon by means of a locking ring having a left handed screw-thread.

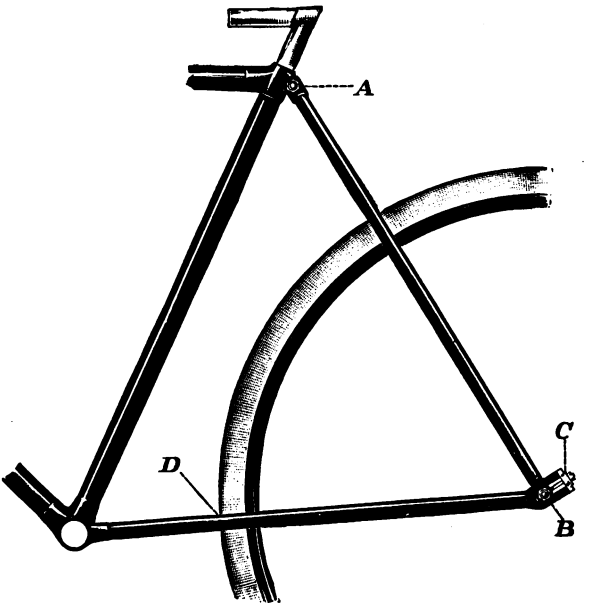

FIG. 162.—Humber Patent Swing Chain Adjustment.

In what is known as the "Cheeta" bottom bracket, which forms the subject-matter of a patent, No. 18,639 of 1895, both cups are firmly locked in position by one screw.

Figs. 160 and 161 show, in plan and side view, the Humber tandem or triplet swing adjusting bottom bracket, the construction of which will be obvious from the said views. To effect the adjustment, the nuts marked A, B, and C

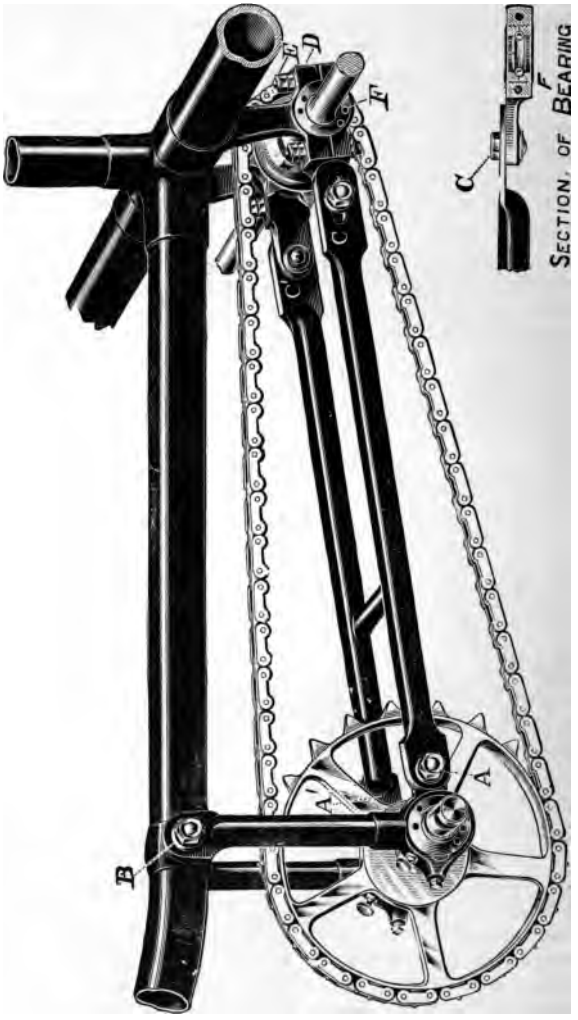

FIG. 163.—Humber Tricycle Swing Chain Adjustment.

must be first slackened, and the push or adjusting screw D screwed up, or inwards, so as to take all the slackness out of the chain, after which the above nuts must be again properly screwed up or tightened.

Fig. 162 shows their swing chain adjustment, patent No. 8,890 of 1890, applied to a safety rear-driving bicycle. To tighten the chain, the nuts B, one of which is situated on each side of the back wheel axle, should be first slackened, as also the nut A at the top end of the swinging back stays. The small nuts C, which operate the drawbolts (one of which only is shown in the drawing), should next be screwed up, taking due care that the adjustment so effected is equal on both sides of the machine, which can be ascertained by observing whether the clearance of the wheel at the point D is the same on both sides. Before screwing or tightening up the nuts A and B, care should be taken to see that the recesses in the saddle stays at B fit properly on the shoulders of the cones.

Fig. 163 illustrates a swing adjustment for tricycles constructed by the same firm. The adjustment is effected in this case by first slackening the nuts marked in the drawing respectively, A, A^1, B, C, and C^1, pulling the crank bracket towards the front wheel until the necessary tension is secured, and then tightening up first the nuts C and C^1, to secure the proper adjustment, and finally the nuts A, A^1, and B. The adjustment of the main axle is secured by first slackening the nuts E, E (one of which only is shown in the drawing), and screwing up the cone F to the right by means of the peg or pin spanner or wrench. When sufficiently adjusted, the nuts E must be again screwed up. The section is of the bearing marked D in Fig. 163.

It will be seen on looking at a modern tricycle that there are four separate bearings supporting the main axle, each of which bearings has two cones, both of which should be adjusted at the same time, instead of one only as was the case with the bottom bracket of a safety. The object of this adjustment is to make the balls run absolutely in the centre of the ball race on the main axle itself. To effect this the points at which the balls come in contact with the two cones must be made exactly equidistant from the centre of the ball race on the main axle. It is, of course, apparent

that if one of the four bearings be adjusted, the remaining three will be thrown out of line, and it is therefore absolutely essential that all the bearings should be equally adjusted. This is of the utmost importance, as the most trifling difference between the adjustment of these four bearings would cause a very serious and perceptible difference in the running and wearing qualities of the machine. The bracket axle of a tricycle is supported on bearings similar to the main axle, two only being provided, however, instead of four. These two bearings are adjusted in a precisely similar manner to the above.

Fig. 164 shows the Humber detachable crank and gear

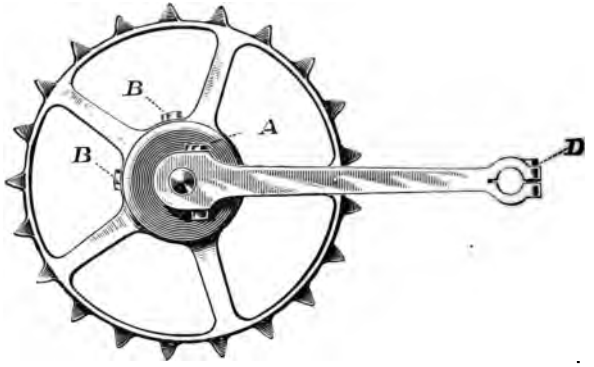

FIG. 164.—Humber Detachable Crank and Gear Wheel.

or chain wheel. In order to remove the chain or sprocket wheel for the purpose of altering the gear, &c., having first taken off the gear case, if any, and the pitch chain, unscrew the nut and knock out cotter pin A, by which the crank and chain or sprocket wheel are secured to the axle. Next take out the locking screws and wedges B, which secure the crank and chain wheel together, when the latter can be unscrewed from the boss of the crank. If a chain wheel of larger or smaller diameter be substituted, the chain must of course be either lengthened or shortened to suit. The chain wheel is placed in position by proceeding in the obverse manner to that employed for its removal. (See also Fig. 158.)

In the Preston Davies bottom bracket bearing shown in Fig. 165, three double conical pieces G, E, and E^1 are employed, and the outer cone pieces B, B^1 are screwed into the tubular piece or barrel D, instead of upon the axle C. In other respects the arrangement of the bearing parts resembles that of Mr Davies' hub, which has been already described and illustrated with reference to Fig. 48. K, K^1 are set screws for locking or fixing the said cone pieces in position. The treble rows of balls H are placed at that end of the axle C upon which is intended to be fixed the sprocket or chain wheel.

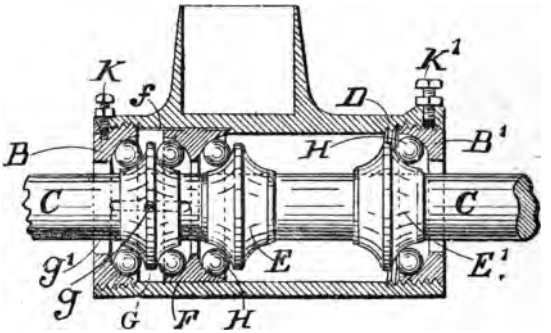

FIG. 165.—Preston Davies Bottom Bracket Bearing.

Fig. 166 shows a portion of a form of chain and sprocket wheel, patented by W. S. Simpson, No. 25,150 of 1894. This chain, which is known as a lever chain, is supposed to give a gain of power. The construction of the links of this chain is such that the friction between them and the back sprocket is probably lessened, hence the possible slight advantage derivable from its use. The idea, however, that any gain of power is thus attainable, may, in the writer's opinion, be at once dismissed as absurd. The principle of the conservation of energy renders the making of power out of nothing, or the gain of power without a corresponding expenditure of energy, impracticable.

This chain has been so much discussed lately, and such extraordinary views promulgated by those who presumably

should know better, that the following extended extract from a clever letter upon the subject which appeared in *Cycling* of 18th April 1896, signed "E. W. T.," will be of interest, giving, as it does, a clear exemplification of the working of the Simpson as compared with the ordinary chain :—

"The Simpson chain does not give any gain of power, as I shall endeavour to point out, except in so far as it does away with friction (at least in theory) between it and the back sprocket or gear wheel. This, with your permission, I shall also endeavour to point out.

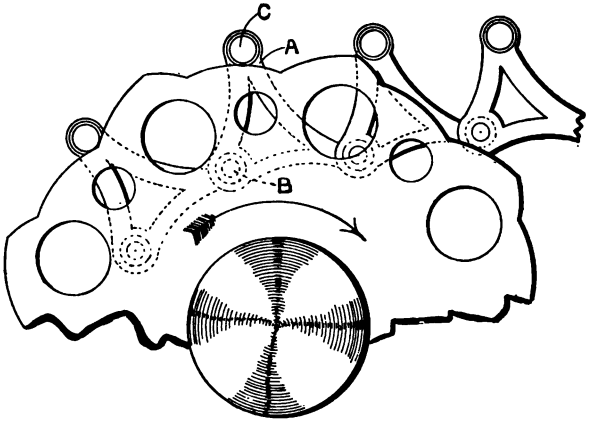

FIG. 166.—Simpson Lever Chain and Sprocket or Chain Wheel.

"Figs. 167 and 168 on the accompanying diagram are examples in statics.

"Fig. 167.—A and B are two fixed points, round which arms A E and B F, are capable of turning. Points taken at C and D are joined by a cord, say. Forces are applied at E and F in the direction of the arrows, and the system is supposed to be in equilibrium. We will suppose, for the sake of example, that a person is pulling at F, and tending to pull against something at E. The line of transmission of power is therefore C D.

"Fig. 168.—A E and D F are as before, but the power is transmitted at C to an intermediate arm C J, turning round

a fixed point G. The power is transmitted from G J to A E, along line J H.

"It is clear to any one who has a knowledge of elementary mechanics (statics) that the same forces must be applied

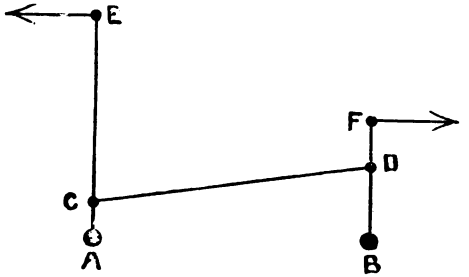

FIG. 167.—Diagram showing Transmission of Power by an Ordinary Block Chain.

at E and F in both figures to keep the systems in equilibrium.

"Fig. 167 represents the transmission of power in the case of an ordinary block chain.

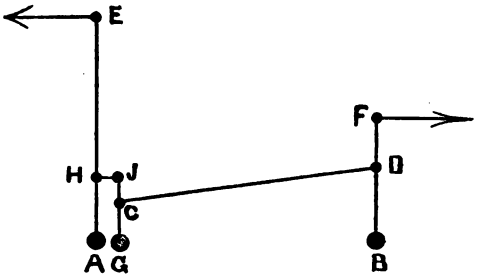

FIG. 168.—Diagram showing Transmission of Power by a Simpson Lever Chain.

"Fig. 168 represents the transmission of power in the case of the Simpson chain.

"In Fig. 167, F represents the point of application of power by the foot, D where the chain comes on to the front

sprocket or gear wheel, B the centre of pedal axle, A the centre of the back wheel, C where the chain leaves back sprocket or gear wheel, E a point on the circumference of the back wheel.

"In Fig. 168 F represents the point of application of power by the foot, D where the base of the chain link comes on to the front sprocket wheel, B the centre of the pedal axle, C where the base of the chain link leaves the back sprocket wheel, J where the apex of the chain link transmits the power to the back sprocket wheel at H. In carrying out the simile, H J would become coincident, as the

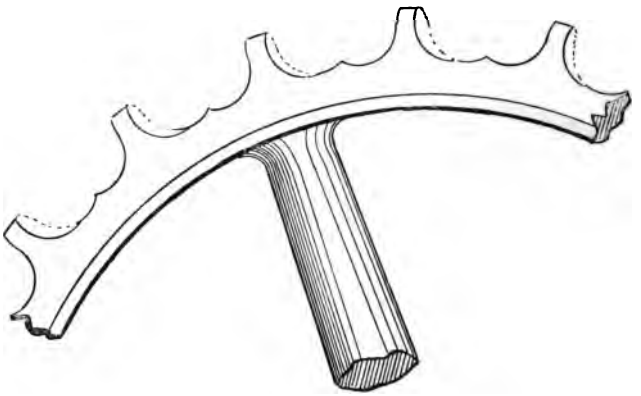

FIG. 169.—View showing Wear of Teeth of Driving Chain or Sprocket Wheel.

point of application of power, and point of reception, along the line H J would be one and the same.

"Hence it is clear that the only advantage a Simpson offers is that it allows a larger back sprocket wheel (radius A H, as against A C, to be used. This advantage, which represents reduction of friction between the back sprocket wheel and chain, is covered by the fact that (theoretically) there is *no* friction between the chain and back sprocket wheel.

"As a link of an ordinary block chain leaves the back sprocket wheel, it turns round pin. The power is applied

to the sprocket tooth by means of pin and block; hence, as it leaves the tooth, no friction exists between it and the tooth, the friction being between the pin and the block. As block leaves it turns round pin, and at the same time its under face rubs on the front part of the tooth; hence there is friction between the block and the tooth in addition to the friction between block and pin. It is clear, therefore, that there is in an ordinary chain always friction when each block commences to leave the sprocket wheel.

"Fig. 166.—As link A leaves the back sprocket, it turns round pin B. Link A only engages with sprocket by means

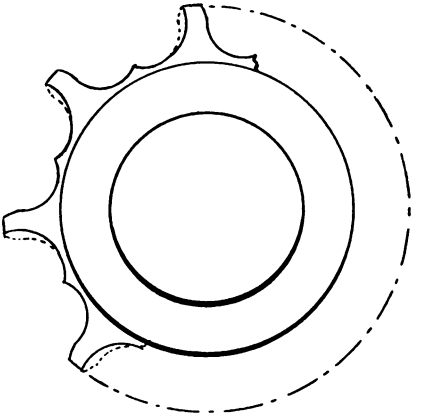

FIG. 170.—View showing Wear of Teeth of Driven Chain or Sprocket Wheel.

of its rollers at C, which are out of contact with sprocket directly link begins to leave wheel. The links are all the same, hence (theoretically) there is no friction between the chain and back sprocket.

"This is the only advantage which a Simpson chain possesses over an ordinary chain, and it in nowise minimises friction between the links. I have heard a good mechanic say, and one who takes an interest in the chain as a mechanical invention, that the chain is about one-half per cent. superior to an ordinary chain."

Although a well-designed and finished sprocket wheel

and pitch chain, especially of the epicycloidal* pattern, are really a first-rate and admirable piece of mechanism, there is still a considerable amount of friction and of wear of the parts when in use. This wear is shown in Figs. 169 and 170, which represent the appearance of the ordinary chain or sprocket wheels removed from a bicycle after being in moderate use for a few months only, the wear on the teeth of the driving wheel and the wear on the driven wheel being indicated in both instances by the dotted lines, which represent the original outlines of the teeth in each case.

Fig. 171 shows one of the intermediate pieces or blocks of the chain in use on the sprocket wheels shown in Figs. 169 and 170. The wear on the block is shown by the dotted lines, which give the original dimensions of the said block.

Numerous attempts to overcome this loss by friction and rapid wear of the parts have been made by employing

FIG. 171.—View showing Wear of Pitch Chain.

roller chains, roller teeth, ball or spherical teeth, cam gearing, &c., the first and the two latter of these plans seeming to present the most feasible methods of reducing the said friction and wear of parts to within reasonable bounds. As regards the best of these arrangements, however, it must be borne in mind that the proportion of friction due to the working of a well-made chain gearing of ordinary construction, say with well-designed epicycloidal teeth, is very small, being not more than, as has been already stated, about 1 per cent., and that, therefore, a saving of the entire friction thus caused, even were it possible, would not amount to any great thing. These various devices seem to be, therefore, more interesting as experiments than of any practical value.

Ball or spherical teeth for use in cycle driving gear seem to be the invention of Charles Lock, and a patent therefor

* For method of setting out epicycloidal teeth see pages 306, 307.

was granted to him in 1889, No. 4,708. According to his invention, the teeth of the gear wheel are composed, as shown in Fig. 172, of balls or spheres *b*, which latter are located in sockets in the rim of the wheel *a*, so as to project sufficiently therefrom to form teeth. To admit of the introduc-

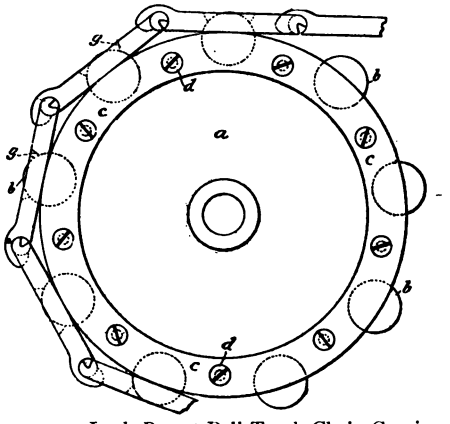

FIG. 172.—Lock Patent Ball Tooth Chain Gearing.

tion of the balls or spheres *b* into their sockets, in which they are inserted for slightly more than half their diameter, so as to prevent their falling out whilst being free to rotate in every direction therein, a loose or removable ring *c* is

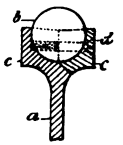

FIG. 173. — Lock Patent Method of Mounting Ball Teeth.

FIG. 174.

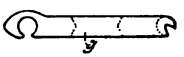

FIG. 175.

Lock Patent Pitch Chain.

provided upon the rim, as is more clearly shown in the sectional view (Fig. 173). The ring *c* is secured in place by screws *d*.

To place the balls or spheres closer together than can be conveniently done when they are situated in a single circum-

ferential row, they are sometimes placed in two or more rows, the balls of each row being located opposite the spaces of the other rows.

Figs. 174 and 175 show in plan and side view a single link of the pitch chain used, which is provided with recesses *g* to receive the projecting portions of the ball or spherical teeth *b*. This chain is of a detachable type, and forms the subject-matter of another patent granted to the same inventor, viz., No. 12,240 of 1888.

Two other forms of chain or sprocket wheels, with ball teeth and driving or pitch chains, which are claimed to be improvements on Lock's, are illustrated in Figs. 176 to 191.

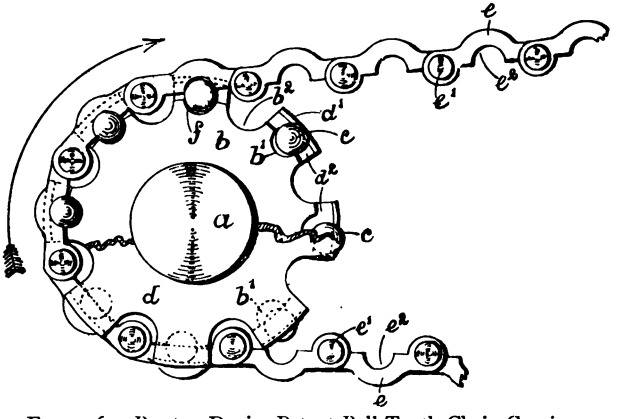

FIG. 176.—Preston Davies Patent Ball Tooth Chain Gearing.

The first of these, which is shown in Figs. 176 to 178, was patented by Preston Davies in 1895, No. 18,192.

Fig. 176 shows in sectional elevation one form of the gearing. *a* is the hub of the driving wheel. It will be seen that the ball or spherical teeth *c* are mounted in peripheral grooves or recesses b^1, formed in a collar or ring *b*, which latter is screwed with right-handed threads upon the said hub *a*, and is clamped or held between discs or collars *d*. The disc *d*, which is placed upon the innermost side of the collar *b*, is carried upon a plain recessed portion of the hub *a*, and the collar *b* is screwed with a

right-handed thread upon a correspondingly screw-threaded further reduced part thereof. The outermost disc *d* is provided with a left-handed thread, and is screwed upon a correspondingly screw-threaded still further reduced portion of

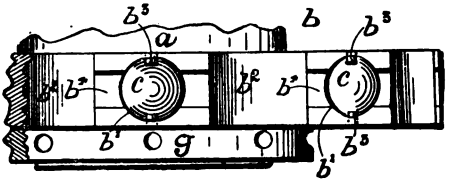

FIG. 177.—Modified Arrangement of Preston Davies Patent Ball Tooth Chain Gearing (Plan).

the hub *a*. The discs *d* are provided, moreover, with annular grooves or recesses d^2, within which and the sockets or recesses b^1 in the ring or collar *b*, the balls or spheres *c*

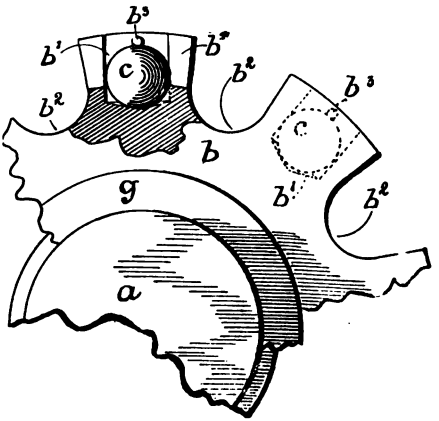

FIG. 178.—Modified Arrangement of Preston Davies Patent Ball Tooth Chain Gearing (Side View).

are retained, whilst at the same time permitted a certain amount of play.

The pitch or driving chain consists of links *e*, which are jointed as shown at e^1, and are provided with recesses or

sockets e^2 adapted to engage with the balls or spheres c when in position upon the wheel. The wheel is recessed or cut away, as shown at b^3 and d^1 to admit and provide clearance for the pivot points of the links e.

This wheel rotates in the direction indicated by the arrow, and the outermost disc d is shown partly broken away, and the chain engaging with the balls or spheres c, a portion of which latter are, when the wheel is at rest, partially embedded in the sockets or recesses b^1 in the collar b. Upon turning the wheel, however, through a certain angle, the ball c, which one of the chain links is leaving, will partially rise from its socket with a rolling motion, as shown at f in the drawing, and thus, it is claimed, greatly reduce the friction between the parts.

Figs. 177 and 178 are a plan and a side elevation, partly

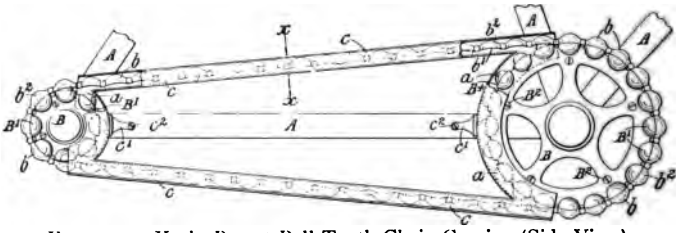

FIG. 179.—Kotin Patent Ball Tooth Chain Gearing (Side View).

in section, showing another method of mounting the balls or spheres c in the wheel, which consists of drilling radial holes therein, and retaining the said balls in place by pins b^3. b^4 is a groove cut in the periphery of the wheel to admit the chain e.

The second type of ball teeth for the chain or sprocket wheels of cycle chain driving gear, which, like that just described, is also an improvement upon Lock's ball gear, forms the subject-matter of patents granted to Adolph Kotin in 1896, No. 1,733, and of a further application in the same year, No. 15,084. It comprises, as shown in Figs. 179 and 180, gear or chain wheels B mounted in the usual manner upon the frame of the cycle, a portion of which latter is shown at A. These chain or gear wheels are formed in two parts vertically, and are provided with caps

or sockets B^1 upon their rims, wherein are mounted hardened steel or other balls or spheres *a*, a portion of each of which latter, to a point slightly above its centre, being enclosed in the said socket, so that it will be prevented from quitting it, whilst at the same time it will be capable of revolving freely in every direction therein. In the pattern under consideration, the toothed or sprocket wheels are formed, as before mentioned, in two parts, and one-half of

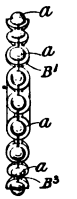

FIG. 180.—Kotin Patent Ball Tooth Chain Gearing (End View).

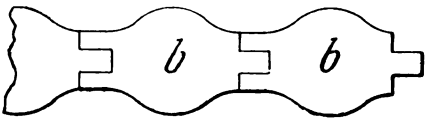

FIG. 181.—Kotin Patent Improved Pitch Chain (Plan).

each of the said sockets is situated in each part, a washer B^3 (Fig. 180) being interposed for purposes of adjustment to allow for wear. The two parts of the toothed or sprocket wheels are firmly connected together by screws B^2.

An important feature in this gear is the provision of means for enabling the driving or pitch chain to more

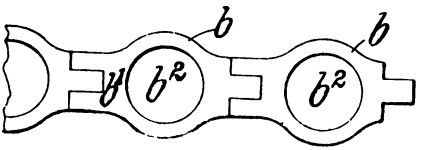

FIG. 182.—Kotin Patent Improved Pitch Chain (Underside View).

readily adapt itself to its curvature as it passes around the chain or sprocket wheels, which in driving gear of this description are of necessity formed of different diameters. For this purpose each of the links *b* of the driving or pitch chain (shown more clearly in the enlarged views, Figs. 181 and 182) is provided with a working surface b^1, that forms an arc of the circle of one of the chain or sprocket wheels (in the drawing that of the driven wheel), and on the

other chain or sprocket wheel are formed peripheral undulations or arcs as indicated at B^4, each of which is struck with the same radius as that of the smaller wheel. To enable the links *b* of the driving or pitch chain to engage with, or upon the projecting portions of the balls or spheres *a*, a recess b^3 is formed in each of them. In some cases the recesses b^3 in the links *b* are enlarged internally, as shown

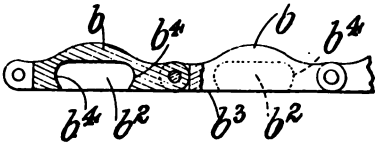

FIG. 183.—Modified Form of Kotin Patent Improved Pitch Chain.

in Fig. 183, so that the outer edges of the said recesses only will come in contact with the projecting portions of the balls or spheres, thereby reducing friction, and also the liability to accident by reason of the chain riding upon the balls, should the recesses, or any one of them, become clogged with dirt. Air holes are sometimes formed in the links.

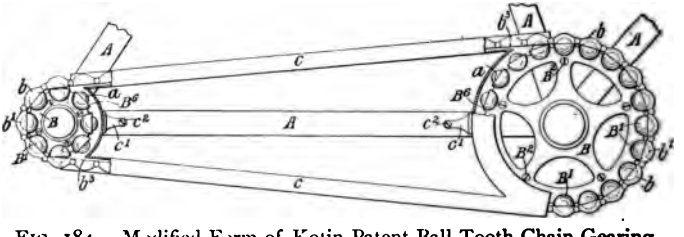

FIG. 184.—Modified Form of Kotin Patent Ball Tooth Chain Gearing.

In the type of gear illustrated in Fig. 184, the difficulty respecting the driving or pitch chain gripping the balls upon the wheels, when the latter are of different diameters, is overcome by forming thereon peripheral flat surfaces B^6, and corresponding flat working surfaces b^3, upon the chain links *b*. *c* is a guard which is made either of rectangular form, as shown in Fig. 185, which is a transverse section on the line *x*, *x*, Fig. 179, or trough-shaped so as to enclose

the driving or pitch chain on three sides only. The guard *c* is secured to the frame A by lugs c^1 and screws c^2.

Several methods employed for mounting the balls or spheres *a* are shown in Figs. 186 to 191. In those shown

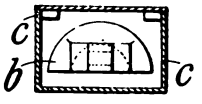

FIG. 185.
Chain Guard.

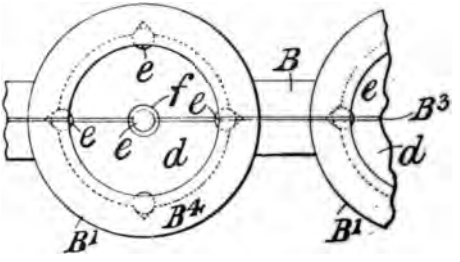

FIG. 186.—Kotin Patent Method of Mounting Ball or Spherical Teeth.

in Figs. 186 to 189, the large or main balls or spheres *a* are supported upon small supplementary balls or spheres *e*, which latter are placed in conical recesses *f* in the enlarged portions *d* of the main recesses or sockets. As will be

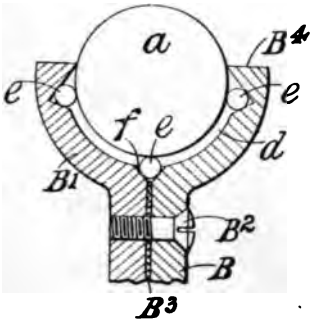

FIG. 187.—Kotin Patent Method of Mounting Ball or Spherical Teeth.

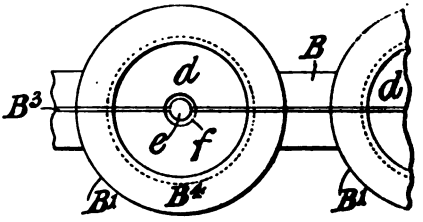

FIG. 188.—Kotin Patent Method of Mounting Ball or Spherical Teeth.

seen from the plan views wherein the main balls *a* are removed, five supplementary balls are employed in the arrangement shown in Figs. 186 and 187, and one in that shown in Figs. 188 and 189. The complication entailed

by these ball seatings would apparently not be compensated for by any gain secured in diminution of friction, at least under ordinary conditions.

In the plan of mounting shown in Figs. 190 and 191, the balls or spheres are carried in a circumferential groove B^5,

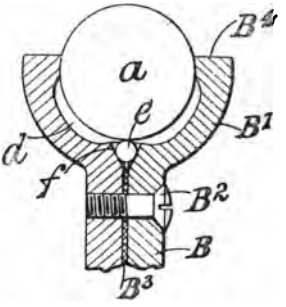

FIG. 189.—Kotin Patent Method of Mounting Ball or Spherical Teeth.

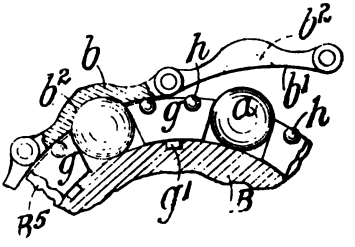

FIG. 190.—Kotin Patent Method of Mounting Ball or Spherical Teeth.

which is formed between the two parts or halves of the chain wheel B, the upper inner edges of the said groove being preferably formed slightly overhanging so as to retain the said balls or spheres in position therein. To retain the balls or spheres *a* at suitable regular distances or intervals apart, distance pieces or blocks *g*, secured or clamped in position between the two parts of the wheel B, and further retained in place by steady pins g^1, are employed. To provide a rolling surface for the working face of the pitch-chain to run upon, and thus further to reduce the friction between the latter and the wheel, small balls *h* are let into holes drilled partially in the edges of the upper surfaces of the distance blocks *g*, so that the said balls *h* project a certain distance therefrom.

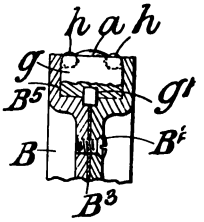

FIG. 191. — Kotin Patent Method of Mounting Ball or Spherical Teeth.

From observations made by himself, on the behaviour of ball driving gear, and from further observations of the

results obtained from exhaustive experiments conducted by others, the author considers that properly designed driving gear of this type is undoubtedly somewhat superior to the ordinary forms of chain gearing. At the same time, however, he does not think that the ball or spherical teeth revolve when mounted in sockets, as in Lock's and Kotin's arrangements, to any appreciable extent during actual work, and he is therefore of opinion that the gain is here due to the hemispherical shape of the teeth, which allows of a quick relief, and does away with the grinding action which takes places to a certain extent with the common chain or sprocket wheels and pitch

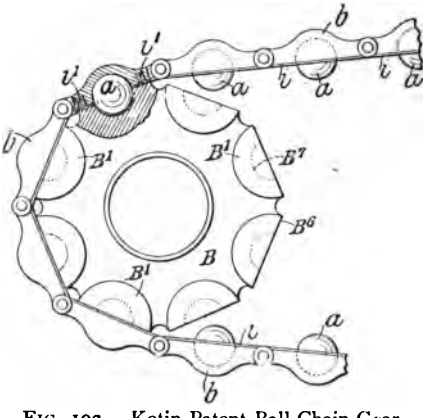

FIG. 192.—Kotin Patent Ball Chain Gear.

chain, as has been already mentioned on pages 181 and 182. In Davies' ball or spherical toothed wheel, the balls being loosely mounted, roll a certain distance when the chain is on the point of leaving them, as has been already mentioned. Another form of ball tooth patented in this country by two American inventors, R. F. and J. A. Rimmington, No. 20,230 of 1895, is similar in principle to Preston Davies' arrangement.

From time to time various forms of driving gear with bands, having balls mounted thereon at regular intervals, and adapted to engage in recesses formed in the chain wheels, have been devised. An arrangement of this descrip-

tion, also designed by A. Kotin, is shown in Fig. 192. As will be seen from the illustration, the chain wheel B is provided with open recesses B^7, instead of having balls or spheres *a* mounted therein as before, and the said balls or spheres *a* are so mounted in suitable sockets or recesses in the links *b* of the chain, as to be free to revolve therein, and that a sufficient portion thereof will project therefrom to engage in the said recesses B^7 in the chain wheel. The balls or spheres *a* are retained in position in the sockets or recesses in the links *b* by means of plates *i* secured to the faces of the said links by means of screws i^1, or otherwise. Sometimes the links are formed in two parts, one half of each of the said sockets or recesses being in the one part of each link, and the remaining half in the other part, the balls or spheres being placed in position in the said sockets or recesses, and retained therein in a similar manner to that adopted for those in the wheels B, as previously described. The two parts of each of the links will be held together by the rivets or pins through which the one link is connected to the other.

Another method of attempting to reduce friction between the chain or sprocket wheels and pitch chain is that wherein the teeth of the former are so arranged that they are capable of pivoting through a greater or less angle, and thus, it is supposed, freeing themselves more easily, and with a smaller loss of power, owing to reduction of friction between the teeth and the chain links. Several patents have been obtained for chain or sprocket wheels of this type. Some arrangements consist simply in pivoting the teeth, and allowing them to swing freely through certain angles; in others the teeth are mounted between packing pieces of indiarubber or other elastic material.

Amongst other means of driving that have been devised are pulleys and friction wheels with pneumatic or air-inflated tyres, and pneumatic belts or driving bands. A patent was taken out for the first of these plans of driving by P. L. Renouf and F. Westwood, No. 12,712 of 1894; and for the second plan by the same inventors, No. 12,713 of 1894. In this latter arrangement two equal, or nearly equal, wheels are employed, one of which is internally toothed, and gears with a pinion fixed to the hub of the driving wheel. The

other wheel is mounted upon the crank axle, and is driven by cranks and pedals in the usual manner. These wheels are connected together by an endless band or belt, which latter, when fitted with an air tube, so as to form a pneumatic belt, can be adjusted as regards tension by the inflation of the air chamber.

Fig. 193 illustrates a spring chain or sprocket wheel, which device formed the subject-matter of a provisional application, No. 8,347 of 1892, and was made by the Cycle Components Company Limited. The construction of the wheel will be readily understood from the drawing, wherein one of the side plates is removed, so as to show the interior of the

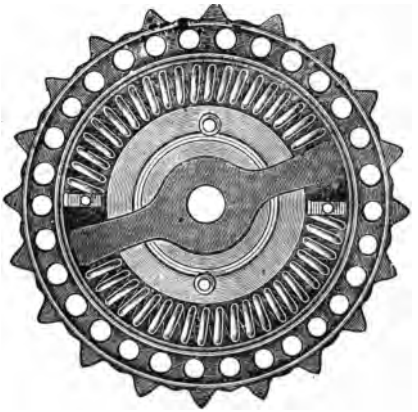

FIG. 193.—Spring Chain or Sprocket Wheel.

spring chamber, the springs being shown slightly under compression as at the commencement of the downward stroke of the pedal.

The use of this spring chain or sprocket wheel is stated to enable a machine of higher gear to be ridden with less expenditure of force, more especially against wind, uphill, and through mud. It is also said that the whole strength of the rider can be utilised in propulsion, and no loss be experienced in overcoming resistance at the dead points of the revolution of the cranks, and, moreover, that all, or nearly all, pedal vibration is done away with.

As it is obvious that no dead centre would exist at the top of the thrust, it is evident that a considerable gain must ensue therefrom, as also that jars experienced when passing over rough surfaces, which would tend to check the momentum with an ordinary chain or sprocket wheel, would be, with the spring chain or sprocket wheel, absorbed by the springs, without taking off anything from the speed of the machine.

Steel driving bands were used upon the Otto and other bicycles or dicycles of this type, suitable means being provided for maintaining the said bands sufficiently tight to grip the pulleys, and avoid slip. The uncertainty of this mode of driving, depending as it did upon the friction between two metallic surfaces to avoid slip, soon led to the interposition of a lining of some suitable material, such as indiarubber or canvas.

Perforated steel bands have likewise been used with toothed wheels or pulleys, and also steel bands having spherical or other protuberances at regular intervals, which protuberances are adapted to engage in corresponding recesses in the wheels.

Plain and perforated bands have been devised in many different forms, and patents have been periodically taken out for such devices, for years past. Some recent patterns will be found described in the patents No. 22,081 of 1894, and No. 5,354 of 1893. A ball-driving band is described in No. 4,337 of 1896.

The defect of all these band driving gears, whether they consist of perforated or plain bands, is that a considerable loss is experienced by reason of the power absorbed in constantly bending them over the pulleys. As against this loss, however, the tendency of the metal to straighten itself would apparently have to be placed—that is, of course, provided the limit of elasticity of the band be not depassed during its flexion. This recuperative tendency would doubtless reduce to a very considerable extent the loss from the above cause.

In driving gears wherein plain bands are used another and more serious loss is entailed by the said bands having to be kept taut, and thereby maintaining the bearings constantly under strain.

An advantage claimed for band driving gear is that the

already described, when dealing with different makes of cycles, bottom brackets, &c. The latest development, however, is to form a combination crank, axle, wherein the axle and crank are constructed from the same bar of steel. This plan seems especially likely to be largely adopted by American cycle manufacturers, with whom it has found much favour.

FIG. 212.—Ordinary Pedal Pin.

FIG. 213.—Pedal Pin for Narrow Tread.

The pedals, of whatever pattern, are rotatably mounted, usually with ball bearings, upon pedal pins, which are screwed into the cranks, or otherwise firmly secured to the latter, the crank end in the first case being sometimes split, as shown in Fig. 164, and the screwed end of the pedal pin or spindle clamped or locked in position by means of a screw, as indicated at D.

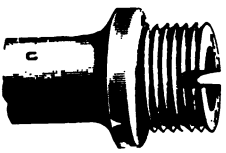

FIG. 214.—Birmingham Small Arms Co. Pattern Pedal Pin.

FIG. 215.—Split Cone Nut Pedal Pin.

Balls were applied to pedals at an early date to reduce friction between the pedal levers and their pins or axles. In the patent of N. K. Husberg (No. 4,660[79]), which has been already referred to, small balls are to be inserted on one or both sides between the adjoining parts so as to form rings or portions of rings round the pins or spindles.

Figs. 212 to 218 show various patterns of pedal pins made

by Townsend, each of which is known by the letter marked thereon. A is a pin of the ordinary pattern. B is a pin having a recessed nut for a very narrow tread. C is a pin of the Birmingham Small Arms pattern. D is a pin fitted with a split cone nut. E is a pin with a nut having a conical inner portion, as shown. F is a right- and left-handed pin. G is a pin adapted to be held in place by a cotter.

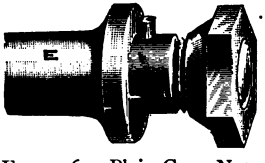

FIG. 216.—Plain Cone Nut Pedal Pin.

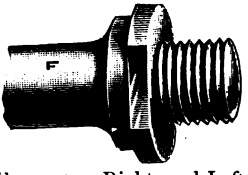

FIG. 217.—Right- and Left-Hand Pedal Pin.

Fig. 219 illustrates the method adopted by Perry & Co. Limited for the attachment of a pedal pin to its crank.

The pedals chiefly in use are those known as rubber pedals, and as rat-trap pedals, but combinations of these two types, and likewise modifications thereof, are also employed.

Figs. 220 and 221 show, the latter one of Perry's and the former one of Townsend's, rubber pedals, which type, owing

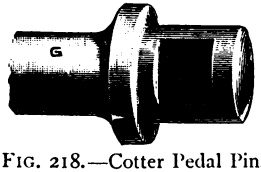

FIG. 218.—Cotter Pedal Pin.

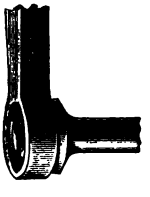

FIG. 219.—Method of Attaching Pedal Pin to Crank.

to the thick surfaces of indiarubber absorbing a considerable amount of the vibration, are more comfortable to use than those of the rat-trap pattern, several forms of which latter are illustrated in Figs. 222 to 228.

A modified form of indiarubber pedal, with very light swinging arms or end plates, is usually known as a butterfly-rubber pedal.

The rat-trap pedal consists of roughened or toothed plates set on edge, and it affords a firmer hold for the foot, and obviates to a great extent the chance of its slipping off when applying any considerable amount of power in driving, which accident formerly constituted one of the chief dangers in bicycle riding, as it inevitably resulted in the centre of gravity being thrown in front of the large driving-wheel of an ordinary, and the rider being pitched forward upon his head. This danger naturally gave rise to a number of inventions designed to render such slipping of the foot practically impossible, and so eliminate this source of accident. These devices consisted of some arrangement

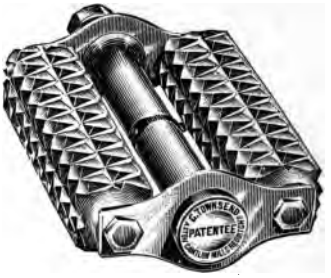

FIG. 220.—Patent Rubber Ball Pedal.

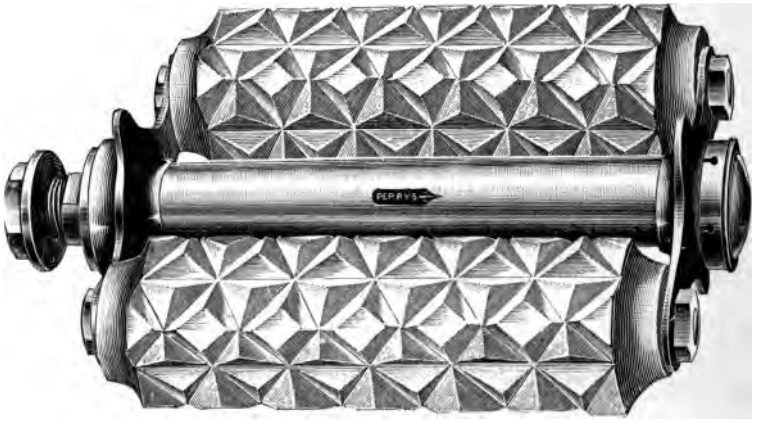

FIG. 221.—Rubber Dust-proof Ball Pedal.

of jaws or grips, which, when the foot was placed upon the pedal, were either moved inwardly, so as to grip or catch the foot, or in the cruder arrangements were so shaped that

the foot would become wedged between them and so held secure.

The first successful grip-pedal of the former type, which was designed by R. E. Phillips, consisted of bell-crank levers,

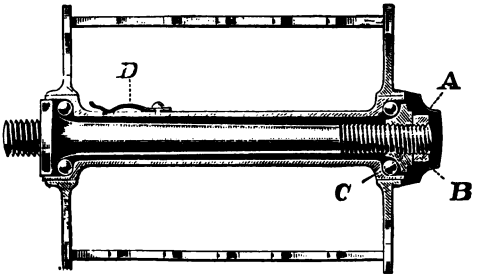

FIG. 222. Rat-Trap Dust-Proof Ball Pedal.

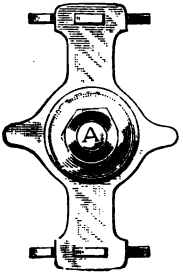

FIG. 223.

the horizontal arms of which received the foot, and the pressure from which, by depressing these horizontal arms, caused the vertical arms of the said levers to move or turn inwards and grip the foot. The instant the levers were

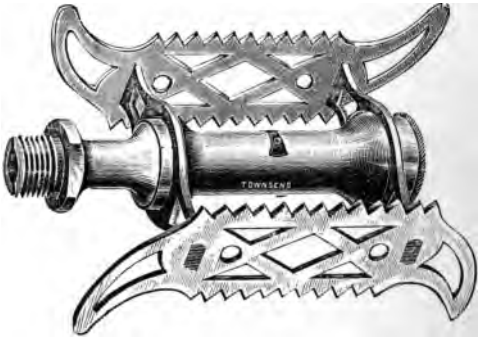

FIG. 224.—Bull-dog Rat-trap Pedal.

relieved of the pressure of the foot they resumed their normal position, and the foot was released. Not so, however, in the case of the grip-pedals fitted with wedging devices, which frequently gripped the foot so tightly that it

was impossible to immediately release it, so as to dismount on an emergency; besides, owing to being gripped in this manner, the amount of play of the foot which is absolutely necessary when pedalling was rendered impossible.

The arrangement of Humber rat-trap pedal, shown in Figs. 222 and 223, is fitted, as are all those of modern design, with ball bearings. The adjustment is very simple, all that is necessary being to remove the dust cap A by means of a suitable spanner, slacken the lock-nut B, and screw up the loose cone C until all slackness is found to have been taken up, after which the lock-nut should be screwed up so as to fix or lock the loose cone C in position. To admit of oil

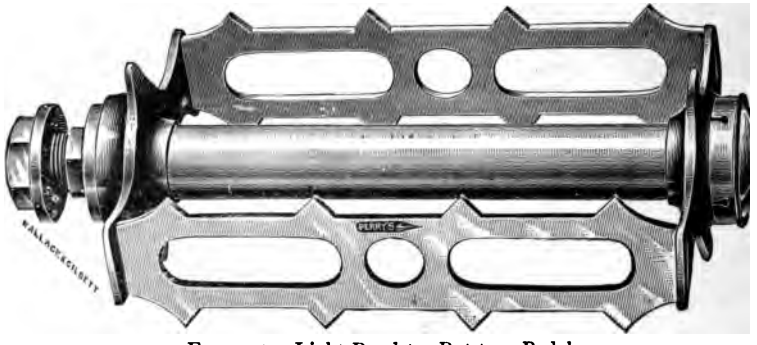

FIG. 225.—Light Roadster Rat-trap Pedal.

being introduced into the bearing, an oil way or hole is provided in the sleeve or barrel of the pedal, which oil-hole is normally closed or covered by the spring cap D.

Fig. 224 is a modified pattern of rat-trap pedal by Townsend, known as a bull-dog pedal.

Fig. 225 shows Perry's pattern of dust-proof ball pedal, for light roadsters. A very light pattern, known as a butterfly rat-trap pedal, is also made, wherein the end plates are dispensed with, and central arms clipped to the sleeve or barrel are employed.

Fig. 226 is a patented type of very light combined pedal and toe-clip, made by Townsend.

Figs. 227 and 228 show two forms of toe-clips for attach-

ment to rat-trap pedals made by Townsend. The first, which is known as the "Unbreakable" toe-clip, is formed all in

FIG. 226.—Patent Combination Pedal and Toe-clip

one piece. The second is a pulling type of toe-clip. The shape of these toe-clips, as also the method employed for

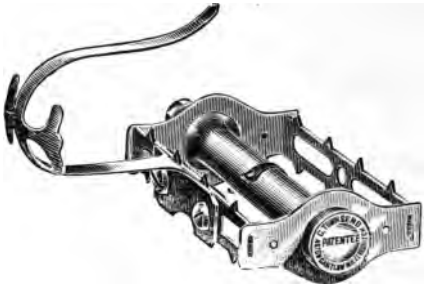

FIG. 227.—Unbreakable Toe-clip.

securing them to the pedals, will be obvious from the illustrations.

Figs. 229 and 230 are two patterns of toe-clips made by Perry. That shown in Fig. 229 is a patented form known as the "Victor," it is constructed of best spring steel. Fig. 230 is a Humber pattern toe-clip. Both are fitted with nuts and bolts or screws and fixing plates, the whole being heavily nickeled.

When designed for attachment to a rubber pedal, the toe-

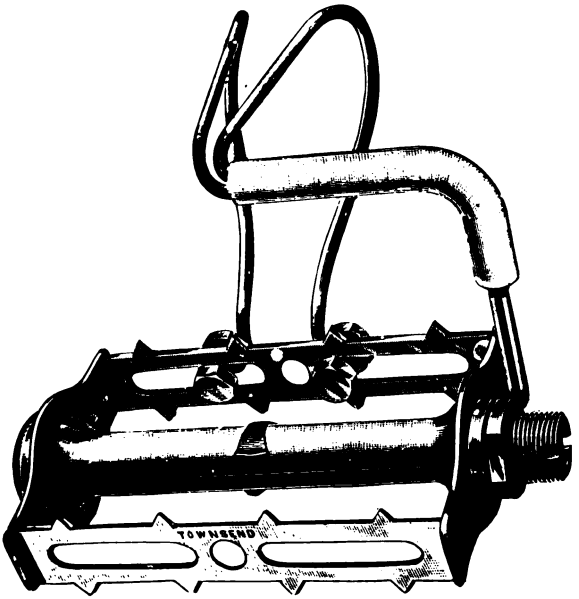

FIG. 228.—Pulling Toe-clip.

clip is usually secured by a suitable clip to the sleeve or barrel of the pedal, and sometimes also to the end plates by hooked extensions, &c.

A toe-clip for attachment to any pedal, which is held in good estimation, is the Zimmy toe-clip. It is made of the best tempered steel, nickel plated, and is bent in such a form as to impart to it the necessary back pulling properties. Another toe-clip, which is both light and efficient, is one patented by Lucas.

The Winton pedal is so arranged that by taking off four nuts rat-trap or serrated side plates can be substituted for indiarubber ones, or *vice versâ*.

Stirrup pedals are used upon some tricycles and other multicycles, such as goods carriers, which are fitted with bent cranks.

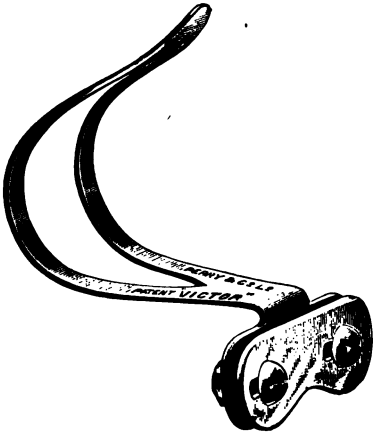

FIG. 229.—Perry Toe-clip.

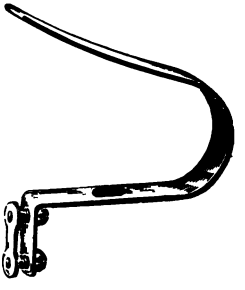

FIG. 230.—Humber Pattern Toe-clip.

SADDLES OR SEATS.

This is an absolutely necessary portion of a cycle, as without it the rest of the machine would be obviously useless. It is likewise a most important part, as upon its proper design depends not only the comfort of the rider, but also in a great measure the healthfulness or otherwise of the pursuit of cycle riding. The ordinary pattern of saddle is, indeed, at the present time the chief point about a first-class modern safety perpetually giving rise to unpleasantness and annoyance, and that not only to the beginner, but quite as much, if not more, to the expert rider, inasmuch as the latter puts it to far more severe tests by long distance rides, and many trained riders even suffer very severely

from saddle-soreness. In spite of this, it is a noticeable fact that up to a comparatively short time back, whilst great improvements had been introduced in every other part of the cycle, the saddles used were little, if anything, in advance of the first more or less crude designs.

It is a fact beyond dispute that the peaks of the ordinary or usual shaped saddles are extremely injurious, and that the rest of the seats afford no proper surfaces upon which the rider can sit. They are, in fact, about the only relic of the old ordinary bicycle or dicycle now left, and were doubtless first copied from a horse's saddle, the shape of which they resemble, but the comfort of which they are wanting in, owing to their necessarily narrow dimensions. The use of the peak is to enable the seat to be safely retained whilst rounding sharp curves, and to afford a support to the body when descending a hill, and in its absence some little practice will be required to attain an equally firm seat, and before the feeling of insecurity which is felt when first using a peakless saddle is got over. One thing seems certain as regards cycle saddles, and that is that no single saddle can possibly be expected to suit every rider equally well, even although it may be designed upon what may appear to be a perfect theory so far as suitability to human anatomy is concerned.

Although, however, improved cycle saddles have been so tardily adopted, inventors, nevertheless, began at an early date to turn their attention to this part.

To reduce the vibration experienced by the rider and render the use of steel springs in cycle saddles unnecessary, J. Cox proposed in a patent taken out in 1869, No. 834, to mount the saddle upon indiarubber or cork balls, cylinders, or discs.

Not unnaturally, having its success in other directions, in reducing vibration, &c., in view, inventors soon turned their attention to the designing of pneumatic saddles or seats for cycles. Pneumatic cycle saddles, indeed, although they have only comparatively lately come into anything like general use, and become really practical and comfortable

hole, aces, are by no means a new idea, for, as far back a

patent specification, No. 1,643, of Johr

made of the matter sufficient to sh

that the idea was even then entertained by at least one person, inasmuch as he proposes to give elasticity to the saddle by forming it of, or supporting it by, an air-bag or its equivalent. It may be here remarked that it seems strange that pneumatic linings have not been substituted for the ordinary padding in horse saddles, an introduction which would doubtless render saddle galls a thing of the past, as there would be no fear of the formation of hard lumps in the padding.

Foremost amongst recent types of pneumatic saddles are those of W. J. Henson, H. J. Burgess, Lycet, Guthrie & Hall, and that known as the "Osoezi."

Henson's, of which Brown Brothers are the sole makers, is known as an anatomical saddle, and is shown in Fig. 231.

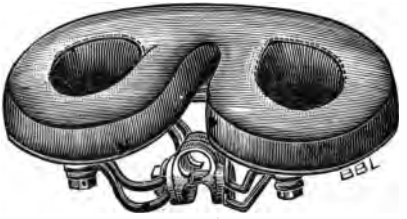

FIG. 231.—Henson Anatomical Pneumatic Saddle or Seat.

It is a saddle without peak, and although perfectly comfortable for gentlemen's use, is most undoubtedly one particularly suitable for lady riders. As will be seen from the illustration, the seat has two separate air chambers, and being cut out in the centre does not become hot. The two depressions for the bones give a firm seat, and are likewise ventilated. The great merit claimed for this saddle is that it admits of the rider sitting in a natural position on the bones, and it is especially calculated for the use of heavy riders. The absence of peak renders it slightly awkward at first for riders accustomed to making use of such support, but allows proper adjustment to suit each particular ... ing been got over, and the ... undoubtedly one which ... ten ...

chambers in the saddle can be effected with the ordinary tyre pump or inflater.

Fig. 232 illustrates the Burgess saddle, or rather duplex seat, and the construction is almost sufficiently obvious from the drawing without further explanation. It consists of two entirely separate and distinct ring air-cushions, each of about five inches in diameter, and resting upon a light steel cup screwed on to a vertical stem adjustably mounted upon the ends of a horizontal bar, and fitted with spiral springs to reduce vibration. The seat is thus, it will be seen, capable of being adjusted to any desired angle by tilting, and the distance from centre to centre of the two cushions can be likewise regulated to suit different riders. Another pattern of this seat is also made without springs.

The seat should be fixed farther back and lower on the

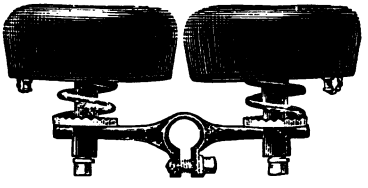

FIG. 232.—Burgess Duplex Pneumatic Seat.

L-pin than an ordinary saddle until such time as the rider has become thoroughly accustomed to its use. This will, of course, take longer with some people than with others, but perfect freedom can always be attained by practice. When it is found desirable to raise the seat, this is effected by means of the L-pin, and the tendency which will be then experienced of undue pressure from the front edge of the pads or cushions, must be counteracted by tilting the seat slightly forward. When adjusted to the proper angle not only will all such pressure be removed, but the rider will be enabled to exert his full power upon the pedals for purposes of propulsion.

Lycet's pneumatic cycle saddle is a peaked air saddle of the suspension type; the seat portion, or what may be styled the saddle proper, is provided with a central depression or hole, and the peak is curved downwards in the form of a

bird's beak. Guthrie & Hall's pneumatic saddle differs from the above chiefly in the method of suspension. The "Osoezi" is an anatomical saddle cut out in the centre, and adjustable through ratchet clips to any angle. The inner tube is readily get-at-able when the saddle is deflated.

Pneumatic saddle covers, ventilated and otherwise, and adapted to strap on any ordinary leather saddles, are also made.

Amongst other improved types of saddles for cycles mention may be made of the "Reform," Christy's, Jarvis', Richardson's, the "Automatic," Pattison's, and those of Brampton, Brooks, Clay & Co., Albion Mills, Brown Brothers, Middlemore, and Lamplugh.

Fig. 233 shows the "Reform" cycle saddle, which is made by Thomann & Büttner, Germany, whose agent in this

FIG. 233.—"Reform" Saddle.

country is Louis Bernstein. It is made in two patterns, that shown in the drawing being the one specially designed for gentlemen's use. This is a peaked saddle, wherein an attempt has been made, and with considerable success, to overcome the objections to which such saddles are open by reason of engendering disease through dangerous and disagreeable pressure. The seat is thickly padded, the edges being well rounded, and the curve of the cantle turning inwardly, so that by the former vibration will be reduced to a very considerable extent, and bruising rendered impossible, and by the latter all injurious pressure upon the spinal column be avoided. The peak is simply a hollow frame, and is depressed at the point of junction with the seat. The ladies' pattern is provided with a shorter peak, but is other-

wise built upon the same lines. The saddles can be fixed at any inclination to suit different riders.

The saddle invented by H. A. Christy, which forms the subject-matter of two patents, viz., No. 960[95] and No. 24,362[95], has two resilient pads or cushions fitting into recesses provided in the seat portion. The peak is hollowed or recessed out centrally, so as to relieve the rider from injurious pressure. E. B. Jarvis' saddle, for which a patent was granted in 1896, No. 15,855, is also of that class which are known as anatomical saddles.

Richardson's saddle, which forms the subject-matter of an application for a patent about the middle of this year (1896), is one which is also designed upon anatomical principles. It

FIG. 234.—Richardson Anatomical Saddle.

has a narrow split fork, and is so curved and cut away as to, theoretically at any rate, avoid all possibility of any injurious pressure arising from its use. An important feature in the construction of the frame is that it is made in two distinct lateral halves or portions, preferably of wood, and so connected together by distance or connecting pieces as to be practically bifurcated from end to end. The frame is preferably covered with leather or other suitable material, and is, in some instances, also padded. This saddle has been, the writer understands, highly approved of by Dr J. W. Anderson and other medical authorities, but at the time of

writing it has not been subjected to the test of being ridden by experts, or by the general public.

The "Automatic" cycle saddle, which is shown in Fig. 235, is one which adjusts itself to a horizontal position when ascending or descending hills. The mechanism for this purpose is simple but effective. It consists in mounting the curved spring wires upon which the saddle is hung upon rollers, supported in bearings upon a suitable curved

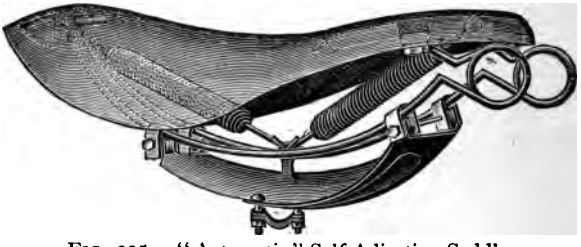

FIG. 235.—"Automatic" Self-Adjusting Saddle.

plate, so that the said saddle is capable of turning through a certain arc, and thus attaining a horizontal position, or approximately so, upon whatever gradient the cycle may be placed. The movements of the saddle in either direction are governed by spiral springs, which tend constantly to bring

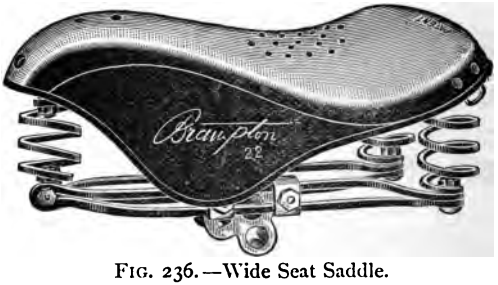

FIG. 236.—Wide Seat Saddle.

it back to its normal position. This saddle is made in two different patterns for use by gentlemen, and also in a special one for ladies.

The Pattison cycle saddle has been for some three or four years before the public, but it has lately been considerably

improved. This saddle is slit or bifurcated from end to end, and has no solid centre either fore or aft. The centre is maintained open by an arrangement which causes the leather to assume a concave form. Sydney Pattison's latest patent is No. 20,663[95].

Brampton saddles are made in a number of different

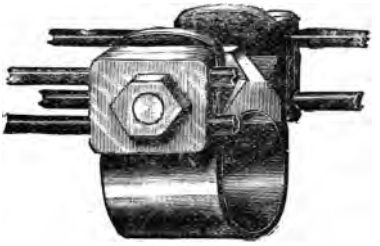

FIG. 237.—Saddle Clip.

patterns, one of which is shown in Fig. 236. The seat of this saddle is wide, and the peak has a good downward curve, and it is generally a very good sample of its class, fitted with simple and effective means for tightening up the leather.

Brooks' cycle saddles are also constructed in many different patterns. They are fitted to the cycles built by

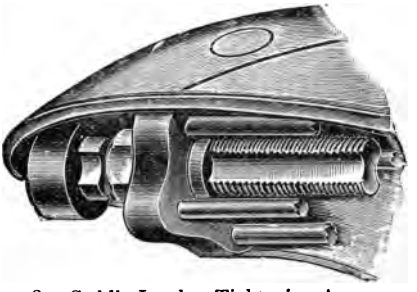

FIG. 238.—Saddle Leather-Tightening Arrangement.

Humber & Co. Limited (see Figs. 5, 11, 15, 16, 17, 18, 21), and are highly spoken of. Fig. 237 shows the clip by means of which a Brooks' saddle is attached to the seat pillar, round which latter it completely passes. The clip is secured by a bolt, on each side of which are two plates, so

recessed as to admit of the springs of the saddle passing between them. These plates are free to turn upon the bolt, and the saddle can therefore be swivelled to any desired angle with reference to the clip. The plates are fixed firmly in position by means of two nuts, one at each end of the bolt, which at the same time secure the clip upon the seat pillar. The above-described clip is equally suitable for back or forward L-pins, or for direct seat pillars.

Fig 238 illustrates the method provided for tightening the leathers of some patterns of Brooks' saddles after they have become stretched from use. The tension is operated by screwing up the nut shown on the left hand side.

Fig. 239 shows a Humber pattern seat lug, and Fig. 240 a Perry saddle pin or pillar of the L pattern. These pillars or pins are also made of the T pattern.

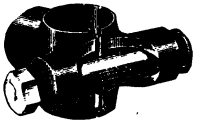

FIG. 239.—Seat Lug.

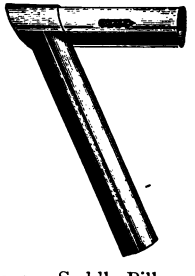

FIG. 240.—Saddle Pillar or Pin.

Space does not admit of giving descriptions of the numerous patterns of saddles made by the other makers mentioned. Several patterns of the ordinary peaked saddles, however, will be found illustrated in connection with the different types of cycles already shown.

Whatever description of saddle may be employed, it is absolutely necessary, to obtain the best results, that it be so adjusted as to give a proper length of reach. To ensure this, the height and other location of the saddle should be such that the foot can easily be placed underneath the pedal in a horizontal position without having to straighten the leg quite out. Too long a reach is a great mistake, as it is bound to occasion discomfort in the saddle, cause most

probably injury to the muscles of the leg, and moreover entails a considerable loss of driving or propelling power. If the reach, on the other hand, be too short, power will be also lost, especially in going up hills. It is, however, unless it be carried to very great excess, in no way so objectionable as the first.

BRAKES.

The brake, if not absolutely indispensable, still forms one of the most important component parts of a cycle. Only

FIG. 241.—Humber Pattern Brake.

two distinct descriptions or varieties of brakes are used, viz., those wherein some kind of brake block or shoe is applied to the peripheral surface of one or more of the wheels, and those wherein a band or strap is so arranged, in connection with a drum or wheel upon one of the axles, that it can be caused to grip, and restrain or retard the same. Prior to the advent of the pneumatic tyre brakes of the former class were almost universally of the pattern known as the spoon brake, which took its name from the shape of the brake piece or block. The spoon-shaped

shoes, however, even in modified forms, are liable to tear up the surface of the rubber tyres, and they are therefore usually replaced in the brakes now in use by shoes or brake blocks of various other patterns. Brakes of the first class are now very numerous, and comprise the following, amongst others:—Brush brakes, roller brakes, indiarubber block brakes, hydraulic brakes, pneumatic brakes, foot brakes, and automatic brakes. Those of the second class or strap

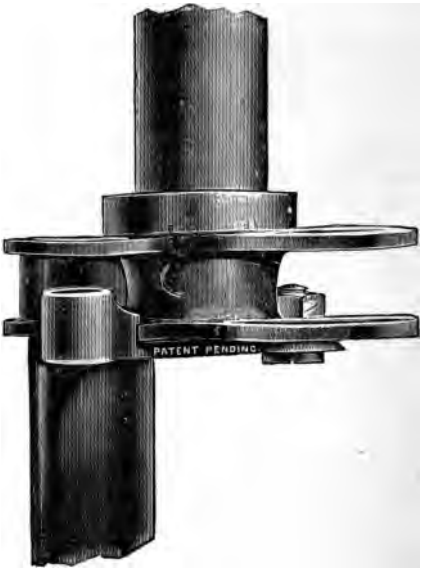

FIG. 242.—Sparkbrook Detachable Brake Lug.

brakes are likewise made in a variety of patterns to suit different machines.

Fig. 241 shows the pattern of brake fitted to cycles built by Humber & Co. Limited. The brake is attached to the machine by means of two clips, as shown at C and D on the drawing. Each of these clips is formed in halves, and secured together by screws or bolts, so as to clamp one of the said clips to the fork crown, as shown at C, and the other to the handle-bar, as shown at D. The brake lever shown on the

left hand side of the drawing is pivoted to the clip D, and its short end is connected through the brake plunger A, which is jointed, as shown at B, with the brake shoe or block, and it is also connected, as shown at C, with the fork crown.

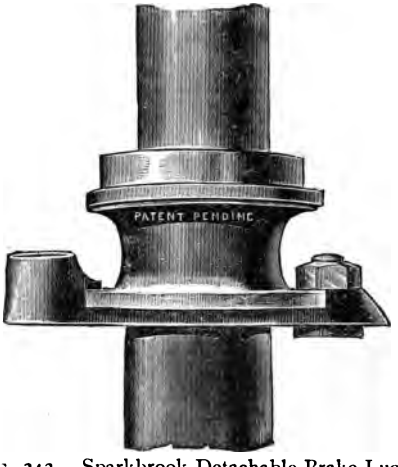

FIG. 243.—Sparkbrook Detachable Brake Lug.

A lever such as that shown in Fig. 241 is usually employed for actuating the brake; sometimes, however, other methods are used, as, for instance, in Drzewiecki's cycle shown in Fig. 9.

The Hollis brake is a new invention wherein a brake of

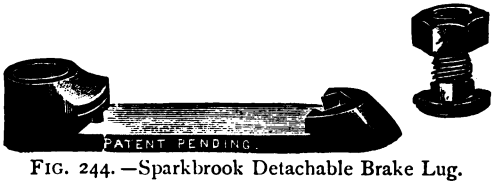

FIG. 244.—Sparkbrook Detachable Brake Lug.

the plunger type can be actuated by one of the handles through connections located within the handle-bar. J. G. Hudson's is a rear wheel brake arranged to act upon the sides of the rim or felloe.

The Sparkbrook Company make a very simple and efficient form of band brake suitable for either safeties or tricycles. Figs. 242, 243, and 244 illustrate the "Sparkbrook"

detachable brake lug. It is a simple, neat, and light form of brake attachment, and very readily removable. By merely removing the little pin and nut shown, the brake lug comes away altogether, leaving no trace of a brake ever having been fitted to the machine. Whilst it is in position it likewise holds the front mud-guard, the whole being capable of removal or of being replaced in a couple of minutes.

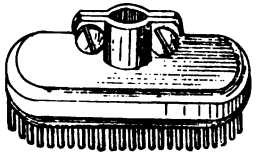

FIG. 245.—Kay Patent Indiarubber Brush Brake.

A form of brake shoe or block much recommended for use with pneumatic tyres, which the ordinary spoon has, as has been already mentioned, a great tendency to tear, unless used with the utmost precaution, is the brush brake. Fig. 245 illustrates Brown Brothers' (Kay's patent) brush brake, which being formed of indiarubber, is very safe for use with pneumatic tyres. Another form of brush brake consists of an ordinary hair brush having a concave face. The objection to brakes of this type is that they are liable in muddy weather to pick up pieces of flint or other hard sharp substances from the tyres and retain them, so that when the brakes are next applied they cut or tear the said tyres.

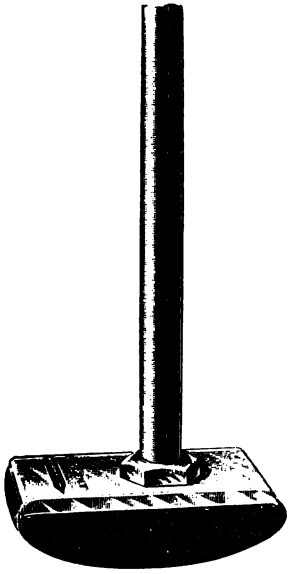

FIG. 246.
Perry Simplex Brake.

The Singer pattern detachable brake has been shown in Fig. 122. Its construction will be apparent from the drawing. The shoe or brake block consists of two square blocks of indiarubber with the corners chamfered off, and is of R. F. Hall's pattern.

Fig. 246 illustrates the Perry Patent Simplex brake, which is fitted with either a detachable, plunging, or a pivoting indiarubber shoe. Amongst other

types of brakes are—The Abingdon indiarubber brake, one form of which consists in a block of indiarubber with a channel face, and another of an inverted V-shaped metal shoe or brake block, the ends of the arms of which are sheathed with indiarubber; Smart's roller brake; Tyrrell's hydraulic brake; a hydraulic brake which consists of a small force pump attached to the short end of the brake lever, and connected through a flexible tube with an expansible pad or shoe arranged in connection with one of the wheels; Rosser's patent pneumatic brake; and the form of patented pneumatic brake made by the Pneumatic Brake Company Limited. The latter type of brake, and one method of attachment thereof to a cycle, is shown in Figs. 247 and 248.

FIG. 247.—Pneumatic Cycle Brake (Air-Ball or Bulb).

Referring to the drawings it will be seen that the brake comprises a hollow indiarubber bulb and a hollow distensible indiarubber pad or shoe, between which two parts air-tight connection is formed by means of a length of flexible indiarubber tube. The pad is held in a metal sheath attached to a bracket, and is capable of being fixed on any cycle. The bulb is fitted with an air-inlet valve and a non-return or discharge valve leading to the distensible rubber pad or shoe. The bulb can thus, it will be seen, be used as a pump to force air into the latter, and any required pressure be brought to bear on the wheel. To release the air, and take off the brake, it is only necessary to press the push piece upon the neck of the bulb, and thus open the release valve.

Various forms of brakes which can be applied by foot pressure have also been designed. One form of this description of brake, and probably the simplest made, consists merely in a flat spring, one end of which is secured by clamps in the top of the steering wheel fork, and the other or free end of which has serrated side projections, and extends over the tyre, and rest normally a short distance from it. To apply the brake either one or both feet are

FIG. 248.—Pneumatic Cycle Brake (Pad or Shoe).

placed upon the said serrated arms or projections, and the free end of the spring is pressed against the tyre of the wheel.

A better but more complicated form of foot brake than the above is illustrated in Fig. 249. As shown it is a combination of foot-rests and brake clamped or fixed to the tops of the fork legs. The two side pieces or arms are bent outwardly and serrated at their free extremities, whilst being pivoted at their other ends to the said foot-rests. A roller

is mounted between the arms, and can be depressed by the action of the foot or feet upon the outwardly turned serrated ends thereof. To normally maintain the brake off the wheel when not subjected to pressure, two springs are employed, one of which springs only can be seen in the drawing.

A great objection to all forms of foot brakes is that one at least of the feet has to be removed from the pedals when putting it in use.

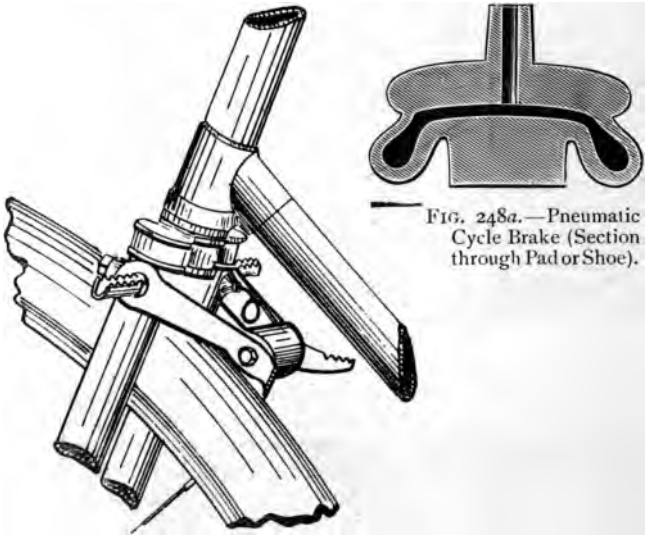

FIG. 248*a*.—Pneumatic Cycle Brake (Section through Pad or Shoe).

FIG. 249.—Foot-Brake.

An ingenious, and at the same time simple form of brake, which is readily applicable to any cycle driven by chain gearing, is the Bailey automatic bicycle brake, which is an invention of American origin. The principle upon which the brake is constructed is to utilise the slackness in the lower reach of the pitch chain, which must exist to a greater or lesser extent whilst the wheel is being propelled forwards, which slackness is instantly taken up directly the rider starts

to back or reverse pedal when desiring to slow down or stop in descending a hill, and on other occasions. This taking up of the slackness of the lower reach, and consequent straightening of the chain, effects the automatic application of the brake. To admit of this action being performed, an arm or lever carrying a small roller at its free end, and connected at its other end with the brake block, is provided, which arm can be so adjusted that under the normal conditions which exist during propulsion, the said roller will be just clear of the inner side of the lower chain reach, but which upon the taking up of the slack as above described will come in contact therewith, and the arm or lever be raised so as to apply the brake. It will be seen that the slightest attempt at back pedalling on the part of the rider will thus operate the brake automatically.

Most of the above brakes could be used upon tricycles or other multicycles, and several applications are shown in Figs. 20, 23, and 25, but the best form for that purpose is some pattern of band brake, as shown in Figs. 21 and 22. Although differing widely from each other in minor points of detail, band brakes all work upon the same principle. The form usually employed on tricycles, &c., consists in a brake drum fixed upon the driving axle, and encircled by a steel band which may be lined with leather. The extremities of this band are so connected with a suitable hand lever, that it can be tightened round the drum when desired, and be thus caused to exert the necessary amount of retarding force.

In the provisional application (No. 4,660 of 1879, N. K. Husberg) already alluded to with respect to ball bearings, a band brake is described which consists of a band connected to a lever, a steel spring being located between leather or other friction surfaces, and a chain or brake band. The spring is formed of two segments of a circle sprung outwards, and carried by the fork. A lever on the steering bar, through wire connections and the chain or brake band, compresses the spring and friction surfaces around the brake wheel when desired.

In an arrangement applicable to central geared tricycles, the brake band is applied to the pedal crank axle, and the extremities thereof are connected to the short arm of a lever pivoted to the frame, or to a bracket secured thereto,

the other or long arm of which lever is adapted to be operated by the foot of the rider.

FITTINGS AND ACCESSORIES.

These comprise lamps, lamp brackets, steps, gear cases, mud-guards, dress guards, bells, cycle horns, lubricators,

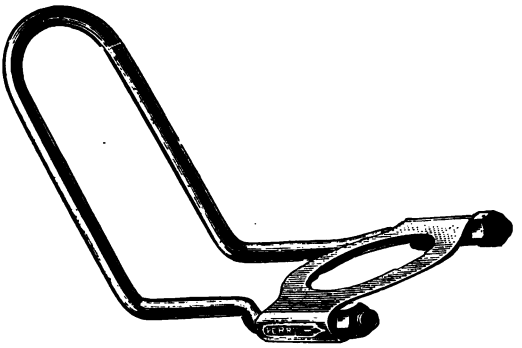

FIG. 250.—Perry Detachable Lamp Bracket.

spanners, cycle locks, cyclometers, parcel &c. carriers, speed indicators, tyre pressure gauges, pumps or inflators, wallets, valises, saddle pads and covers, cycle stands, &c. &c., in endless varieties, and a complete description of which would in itself make a large book.

Figs. 250, 251, and 252 illustrate three different patterns of lamp brackets which will serve as examples of these accessories, and the construction of which is sufficiently obvious from the illustrations and descriptions attached to them.

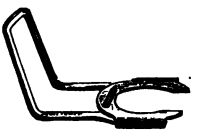

FIG. 251. — Perry Feather-weight Lamp Bracket.

A rider who prefers to exhibit an electric headlight to the many excellent oil lamps procurable, can either have an electric lamp and accumulator, or he may have a small magneto-electric machine fitted to his cycle. In an arrangement on the latter plan which was described in the *New York Electrical World*, some little time back, the current for the small

incandescent lamp, mounted in a reflector, is generated by a small magneto-electric machine, operated by a friction and band wheel from the front or steering wheel of the cycle. This small magneto-electric machine has a shuttle armature, with a thoroughly laminated core. The current generated is collected from the frame of the machine, one terminal being grounded, and from one of the bearings surrounding a slip ring on the shaft; no commutator, it will be seen, being thus employed, and the construction being very simple. The alternating current is carried to a two candle-power lamp of low voltage, which is enclosed in a reflector, which being a double parabola concentrates

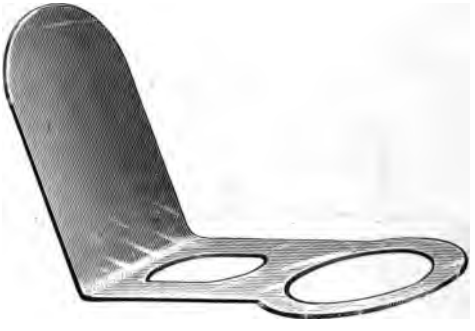

FIG. 252.—Perry Plate Lamp Bracket.

the light at the focus of the outermost parabola, from which latter it is thrown forward in a very powerful beam, illuminating a considerable distance in advance. The slowest movement of the cycle wheel will cause the glowing of the lamp, and the latter has a short stumpy filament which is very unlikely to get broken from any cause other than an excessively high current. The friction wheel is so constructed that it can be readily disconnected from, or moved out of contact with, the cycle wheel tyre, so as to arrest when desired the action of the generator. A suitable dust-guard is also provided for the protection of the transmission mechanism.

C. M. Raymond in his patent, No. 20,300 of 1892, pro-

posed to utilise the backbone of a cycle as an oil reservoir, and to connect the wick tube of the lamp therewith.

An important adjunct to a cycle is a gear case to prevent the access of dirt or moisture to the working parts. A well-known and efficient type is Carter's patent detachable gear case, which is formed in halves, or divided in two parts longitudinally, and which, when in position and the two parts secured together by means of a screw or other fastening, forms a perfectly water and dust tight covering. Amongst the numerous other gear cases in use mention may be made of Bates' patent detachable gear case, which is known as the "Presto," the outer portion of which can be slid off the chain or sprocket wheels and chain by

FIG. 253.—Serrated or Rat-trap Foot-rest.

opening a hinged portion of the larger end; the "Dover" transparent xylonite and papier-mâché detachable gear cases and patent lubricators; Bluemel's transparent celluloid gear cases; Grose's opaque and transparent panelled gear cases; Bransom's leather gear cases, with and without transparent panels; and Brooks' patent gear cases. Combination gear cases and dress or wheel guards are made by Brooks, Grose, and others.

The first record of a mud-guard is to be found in the specification of the British patent, No. 2,165 of the year 1869. The ordinary forms of mud-guards now in use have been already shown in connection with the various types of cycles illustrated. Patent "Paragon" mud-guards and

stay rods, Bransom's mud-guards, wood mud-guards, celluloid mud-guards, and the Griswold rubber mud-guards, as well as the squeegee, and many other patterns, are likewise in use. Plated wire, corded silk, or some other form of laced dress or wheel guards, are required upon ladies' cycles, and similar chain guards are also used. A dress guard is

FIG. 254.—Combined Rubber and Serrated or Rat-trap Foot-rest.

described in the specification of the British patent, No. 361 of the year 1870.

Figs. 253 and 254 illustrate two patterns of foot-rests made by Perry & Co. Limited, the first being an ordinary serrated or rat-trap foot-rest, and the second a combination rubber and serrated or rat-trap foot-rest. One of the many

FIG. 255.—Cycle Step.

FIG. 256.—Pump Clip.

patterns of steps made by this firm is shown in Fig. 255, as likewise a pump-clip in Fig. 256, an oil can (registered design No. 263,290) in Fig. 257, and a patented form of adjustable wrench or spanner in Fig. 258. Another useful form of spanner, which has been in use for some time, is that having ratchet teeth and pawl adjustment.

J. Lancaster in his patent, No. 7,440 of 1894, describes spring plates or clips for attachment to the tyres to prevent slip.

Space does not admit of even enumerating the various other varieties of fittings and accessories, numbers of which display great ingenuity. Those who are not thoroughly

FIG. 257.
Midget Oil Can.

FIG. 258.
Patent Adjustable Spanner.

conversant with them will derive considerable information from a perusal of some of the exhaustive catalogues published by the firms who make and deal in these articles, the manufacture of which forms separate trades, and is carried on quite distinct from that of cycles.

CHAPTER VIII.

The Manufacture of Cycles.

THE building of a cycle, when the greater portion or all of the component parts are obtained from firms making a specialty of their manufacture, can be effected with a comparatively small number of tools, and those, moreover, of simple construction. In the case of large manufacturers, however, who themselves make the majority, if not all, of the parts that go to make up a complete machine, a considerable number of tools, in many cases of a special nature, are employed.

By way of example, the following description of a limited number of the principal operations required in the making of a modern safety bicycle or dicycle of the rear-driven type will be of interest:—

Framework.—The first part to consider is the framework, which in a bicycle of the pattern under consideration, consisting as it does of short and straight members, is a far simpler affair to make than was the case with the backbone of the former high bicycle or ordinary, which was both curved and tapering. The frame of the modern cycle usually consists of solid drawn mild steel tubes, but nickel steel (5 per cent. of nickel) tubes, of which it is sometimes formed, or special steel tubes, such, for instance, as the helical tube* of the Premier Company, are far preferable. A better metal for the purpose than steel would be aluminium, which combines great strength with superior lightness. In any case, however, the tubes, of whatever description they may be, that go to form the several members of the frame, have to be connected together at their points of junction, and

* For a description and illustration of this special tube, see chapter on Component Parts, pages 81-84.

this is a very, if not the most, important part of the operation of making a cycle, and one upon the proper execution of which the future value of the machine largely depends. The method adopted for securing together the parts of a bamboo frame has been gone into already,* and metal tubes only will be dealt with here.

The junctions between the parts of the frame, when the latter is constructed of steel or other metal, are made by means of junction pieces or lugs, consisting of suitable tees, elbows, &c., which are firmly brazed in position. The material and method of making these junction pieces, differing in accordance with the quality of the cycle—viz., malleable castings for cheap, low quality machines, forged stampings for those of a somewhat superior make, and finally, pieces stamped from sheet metal and moulded to the required shape by means of special tools in a powerful press for

FIG. 259.—Gas Blow-Pipe with Central Tap.

machines of the higher grades. They are also drawn cold from ordinary weldless steel tube by means of hydraulic pressure. The forms of these junction pieces are too well known to need illustration. The different tubes composing the framework are brazed into junction pieces suitable to the joints in the usual manner in a gas and air furnace, it being, as before mentioned, absolutely essential to take every care to secure a sound and reliable job. The usual method of brazing is by means of Bunsen flames on a fine coke bed, the said Bunsen flame apparatus being supplied with air under pressure from a compressor or other convenient source. Either ordinary town gas may be used, or that obtained from a special Dowson gas plant. The tubes should be made a good tight fit in the sockets, and not a loose careless one, dependent upon the brazing for being made good.

Fig. 259 illustrates a blow-pipe by Fletcher, Russell, & Co.

* See chapter on Component Parts, pages 80-89.

Limited, with improved control tap arrangement, and gas and air supplies independent and under the control of one finger. Fig. 260 is a gas and petroleum forge and blow-pipe combined. The blow-pipe and blower can be removed and used separately for brazing, and the blow-pipe can be arranged to give a top heat on the coke if desired. This combined forge and blow-pipe, as also the gas furnace shown in Fig. 261, are made by the same firm.

In making the connections between the crank bracket and head an internal ferrule should be driven into the end of the tube, so as to extend for about an inch beyond the point to which the tube is to be inserted into the socket.

FIG. 260.—Gas or Petroleum Forge and Blow-Pipe combined.

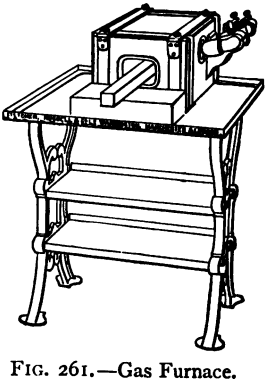

FIG. 261.—Gas Furnace.

The extremity of this ferrule may be slit, or formed what is known as bird-mouthed—a usual pattern is shown separate in Fig. 262, and has been shown in position in Fig. 121. By means of this ferrule the support of the socket is carried for a certain length up the tube, and not only is the strength of the end greatly increased as regards any transverse strain, but the sudden and injurious change from the complete rigidity of the socket to the comparative flexibility or spring of the thin tube is avoided. The frames are, or should be, put together on suitable erecting beds, fitted up as jiggers, and having the necessary guides and supports, in which manner the placing of the parts at their proper angles is ensured.

When the brazing of all the parts has been effected, the frame should be placed upon a similar jigger table, whereon the tubes, which are sufficiently heated near their extremities, are allowed to cool down, whilst all portions thereof are held firmly in place. By this means the crank bracket and the driving wheel forks will be placed in perfectly parallel positions, and the axis of the head being in a true plane to that of the crank shaft will be assured. Crowden's system of hydraulic jointing has been already alluded to in the previous chapter.

Fig. 263 shows an emery band machine by Sterne & Co.

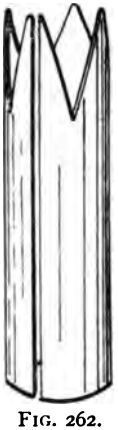

FIG. 262.
Tube Strengthener or Ferrule.

FIG. 263.
Emery Band Machine.

Limited, which is an essential tool for cleaning up the framework both before and after brazing.

A very useful tool, which is especially adapted for use with a drilling machine, but which can also be advantageously employed with a milling machine, or other machine for angular work, is Roper's improved patent angular sliding vice, which is illustrated in Fig. 264. The tool is especially adapted for holding brackets and all kinds of lugs that require to be bored or drilled at any angle, and after being once set, a boy can accurately bore any quantity of brackets for tubing, or any pattern lug, with a certainty

of their being exactly alike in the angles, and the frames can consequently be fitted together with the greatest ease, without having to spring or bend the tubing, which is so often done where the brackets and lugs are drilled on makeshift principles. As will be seen from the drawing, a sliding device at the base fixes the work under the exact centre of the drill or boring bit. A dial marked or graduated in parts of two degrees, enables the work to be set to the correct position without the aid of various other instruments. In connection with the dial and base or bottom slide are stop gauges, which can be set in any position at the

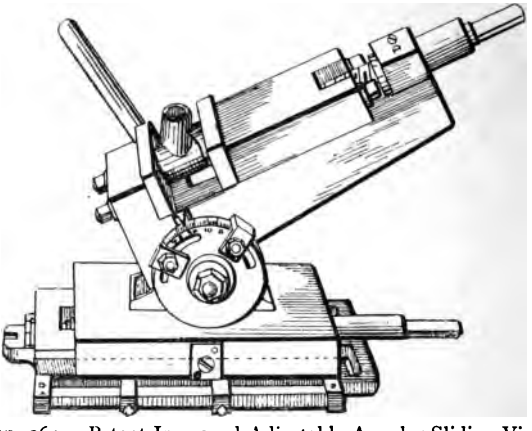

FIG. 264.—Patent Improved Adjustable Angular Sliding Vice.

desire of the workman, thus saving time in resetting, as they only require to be tilted and moved to the stops.

Another most useful tool is the universal cycle jig illustrated in Fig. 265. This appliance, which is Hatton's patent, consists, as will be seen from the drawing, of a cast-iron frame, with a planed base to fix on a lathe face plate, or preferably on a drilling machine table. The head of the frame is bored to receive a series of hardened adjustable guide bushes, arranged for all the sizes of tubes usually employed in the construction of cycles. Immediately under the centre of the guide bush is fixed a horizontal shaft, on which the bottom bracket or lug, &c., is placed. This shaft

is carried on a bracket pivoted to the frame of the machine, and can be readily adjusted to any given angle in relation to the vertical guide bush. The amount of angle is registered by means of the graduated scale on the edge of the frame.

Further angular movements for determining the relation between the main tube lugs of the bottom bracket are secured by a horizontal bar, which is carried on brackets. These brackets, together with the bar, have a radial movement around the axis of the horizontal shaft. The bar is bossed up in the centre, and bored to receive locating

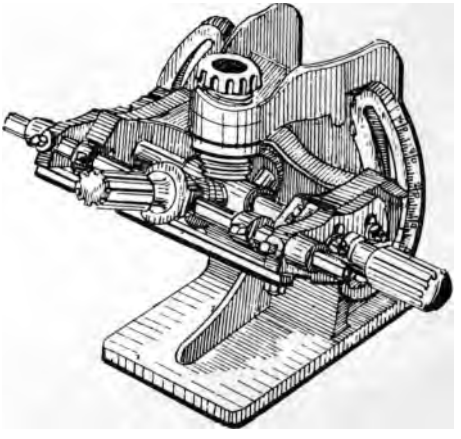

FIG. 265.—Patent Universal Cycle Jig.

plugs. It is also provided with lateral movement, so that back-stay lugs may be operated upon without removing the bracket from the bar. The apparatus admits of the whole of the frame lugs and brackets of a cycle of any pattern being bored, with accuracy as to angle and perfect alignment of tubes in all directions, by a comparatively unskilled mechanic.

WHEELS.—The wheels are formed with metal rims or felloes of two kinds, viz., solid and hollow, the latter being the newer plan, and being the type of rim now usually adopted for the wheels of high grade cycles.

The solid rims are formed by cutting bars of the proper section to the requisite lengths, and slowly rolling them into a circular form in an ordinary three-roll machine in the common well-known manner. The free ends of the rims or felloes are united by brazing, scarf joints being used, and the requisite heat obtained by means of a gas and air furnace of special construction. In making the joints the extremities of the rims or felloes are filed down to form the scarf joints, and one rivet is inserted in each rim to hold the parts together during the brazing operation. It is of vital importance that all the rims or felloes be of exactly the given dimensions, even slight departures therefrom rendering it impossible to secure the usual types of pneumatic tyres firmly in position thereon.

The formation of double or hollow rims or felloes, which class has been already described and illustrated in the previous chapter, differs somewhat in accordance with the particular pattern of rim being made. Shortly, however, the usual mode of procedure is as follows: — Two strips of steel of the proper dimensions are first rolled in the ordinary manner to the required sections, which of course depend upon the particular design of rim or felloe to be made. The strip forming the inner ring of the rim or felloe, however, is usually in all cases of a **U**-shape in transverse section, the depth of the said **U** depending upon the type of tyre to be fitted to the rim, and as it has to sustain the direct pull of the spokes, being as a rule formed of a stouter gauge than the strip forming the outer ring of the said rim or felloe. The said outer ring is likewise either **U**-shaped, or approximately so, in transverse section, and has usually a ledge on one or the other side, or on both sides, to retain the wire rings which are now largely used for fixing the tyre.

The strips having been thus brought to the requisite forms in transverse section are next made into a circular shape in bending rolls in the usual way. The two rings forming the rim or felloe are then placed one within the other, so as to touch at their edges only, and to leave a hollow or space between them. The adjacent edges are lapped over and firmly brazed together, the joints of the rings being located at different points in the circumference

of the wheel, and further strengthened by means of cover plates of thin steel. The spelter used for brazing these joints must be capable of making them sufficiently strong to cause the forcing asunder thereof to break away the metal of the rings, and not to allow of the fracture passing through the brazing itself.

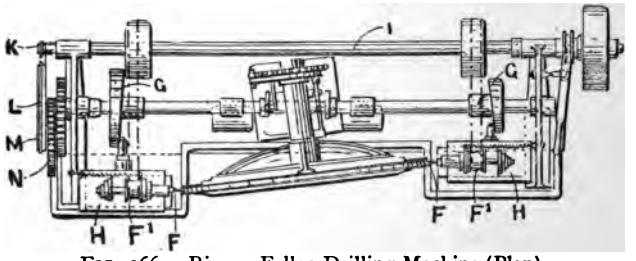

FIG. 266.—Rim or Felloe Drilling Machine (Plan).

For drilling the spoke-holes in the rims or felloes special tools are employed in all large works. One form of machine for this purpose is illustrated in plan in Fig. 266, and in front elevation in Fig. 267. In both these views a rim or

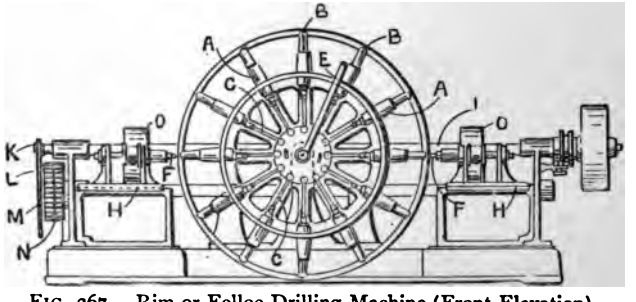

FIG. 267.—Rim or Felloe Drilling Machine (Front Elevation).

felloe is shown in position for drilling. The said rim or felloe is held in place by a chuck, which has a number of radial sockets A, A (Fig. 267), in which are mounted a corresponding number of sliding rods or plungers B, B, which latter can be moved inwards or outwards through links or connecting rods C, C, and a disc provided with a lever E, by rotating

the said disc in the one or other direction, and thus causing the said rods B to press against the inner surface of the rim or felloe, as shown, and hold it firmly in position, or to withdraw the said rods B so as to release the said rim or felloe when it is desired to remove it from the chuck. The chuck carrying the rim or felloe to be drilled is intermittently rotated and held stationary for drilling by suitable mechanism, the step-by-step motion being ensured by a cam, and the forward and backward motions of the drilling spindles F, F, being likewise effected by cams G, G, acting upon the sliding headstocks H, H, upon which the said spindles F are mounted. The arrangement of this mechanism is clearly

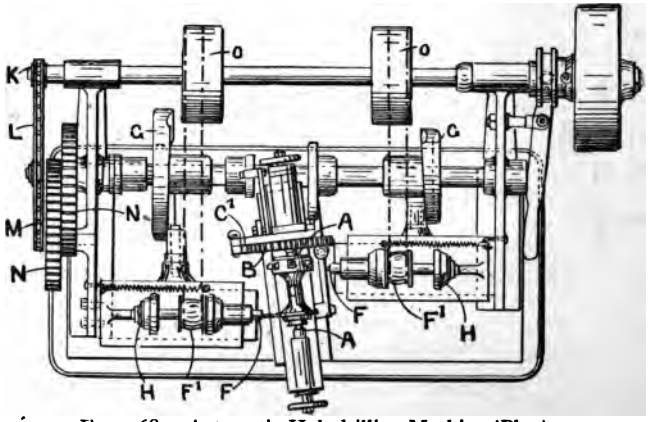

FIG. 268.—Automatic Hub-drilling Machine (Plan).

shown in Fig. 266. The machine is operated from a back or rear-driving shaft I, to which rotary motion is imparted by belt-gearing from any available source of power. On one extremity of the back or rear-driving shaft I is keyed a chain or sprocket wheel K, which through a driving or pitch chain L, and another chain or sprocket wheel M, imparts motion to a set of toothed wheels N. O, O are wide-faced pulleys, keyed upon the said rear-driving shaft I, from which pulley belts, as indicated by the chain lines in Fig. 266, are carried to the pulleys F^1, F^1, keyed upon the drill spindles F, and the requisite rotary motion is thus imparted thereto.

Figs. 268 and 269 are a plan and front elevation of a machine arranged for drilling either direct or radial, or tangent spoke-holes in the hubs. The hub to be drilled is, in this case, mounted between centres A, A, one of the spindles of which has a carrier to hold the said hub securely in position. B is a toothed disc, which is secured upon the carrier spindle, and by means of which it can be rotated through part of a revolution to bring another portion of the hub in place for drilling, and for holding the said hub firmly in position during the operation. The step-by-step movement is ensured by a cam worked by a horizontal lever through a second lever C, coupled to the former by means of a suitable link or connecting rod, and on which second lever is mounted a pawl

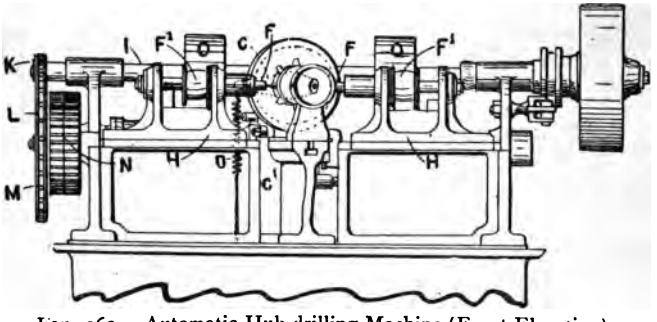

FIG. 269.—Automatic Hub-drilling Machine (Front Elevation).

C^1, which engages with the peripheral teeth on the disc B. When released by the action of the above-mentioned cam, the lever C is moved forward by the spring D, and through the pawl C^1, carries with it the toothed disc B. Another lever holds the parts in position, whilst the drilling of each set of holes is being effected, the said lever being actuated by a suitable cam to release the toothed disc B, and allow of its being rotated or moved through a certain angle as above mentioned. F, F are the drilling spindles, which are mounted in sliding headstocks H, H, to which the necessary forward and backward motions are imparted by the cams G, G, in a manner substantially similar to that employed in the machine for drilling rims or felloes previously described. The drilling spindles are also provided with transverse ad-

justment to render them suitable for operating upon hubs of varying widths. I is a back or rear-driving shaft, carrying at one extremity a chain wheel K, which imparts motion through a chain L, to another chain wheel M, and through the latter to a set of toothed wheels N. O, O are wide-faced pulleys fixed upon the said back or rear-driving shaft I, from which belts, as indicated by the chain lines in Fig. 268, are carried to pulleys F^1, F^1, fixed upon the drill spindles, and the required rotary motion imparted to the latter, all in a manner practically similar to that employed in the previously described machine.

To adapt the hub-drilling machine for forming holes for

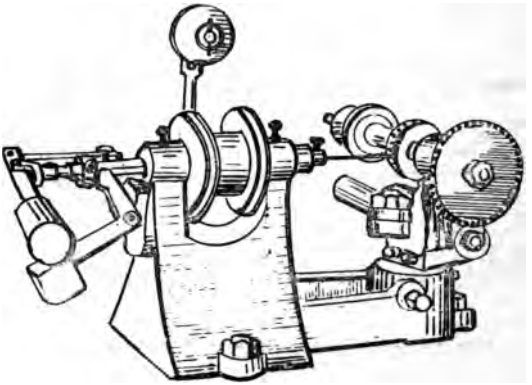

FIG. 270.—Small Hub-drilling Machine.

tangent spokes, the drill spindles F are simply mounted in positions at right angles to that shown in Figs. 268 and 269, so as to enable the said holes to be drilled in the sides of the flanges as is required for that type of spoke.

Fig. 270 illustrates a small hub-drilling machine, suitable for drilling and tapping direct hubs and for drilling tangent hubs. It is likewise fitted with an attachment for screwing the spokes.

The hubs of the wheels require before completion a number of machining operations, all of which could of course be effected by means of the ordinary machine tools to be found in an engineer's shop, but which can be more

readily, accurately, and expeditiously performed by the assistance of special lathes. Such a lathe is illustrated in plan in Fig. 271, and this tool, as also those illustrated in Figs. 266, 267, 268, and 269, are employed in the works of the Premier Cycle Company Limited, by whom they were designed and built.

The self-acting hub-turning lathe shown in Fig. 271, has a rear-driving shaft A, to which rotary motion can be imparted by belt gearing from any suitable source of power to a pulley B, rotatably mounted at one extremity of the said shaft A, but capable of being connected with the latter when desired through a clutch C. From this rear-driving shaft A,

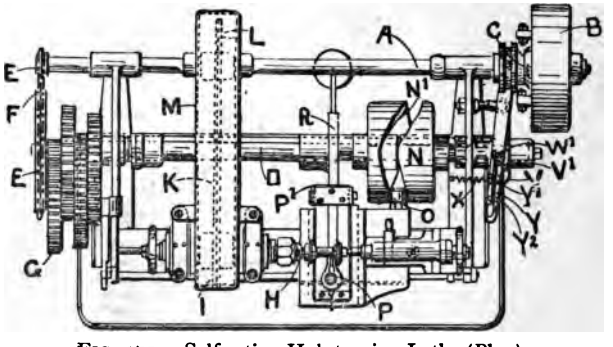

FIG. 271.—Self-acting Hub-turning Lathe (Plan).

rotary motion is communicated to a cam shaft D, through chain or sprocket wheels E, driving or pitch chain F, and toothed gearing G. To impart rotary motion to the head-stock spindle H, a chain or sprocket wheel I is secured thereon, connected through a pitch chain K with another chain or sprocket wheel L, keyed upon the rear-driving shaft A. This chain gearing is enclosed in a case or guard M, and is shown in dotted lines in the drawing. N is a cam having a groove N^1, wherein works a roller O, mounted upon the slide-rest P, and thus effects the longitudinal traverse of the latter. R is an edge cam, more clearly shown in the detail view, Fig. 272, by which the transverse movement of the slide-rest P is operated. S (Fig. 272) is a bell-crank

lever pivoted to the bed of the lathe, the short arm of which lever is connected or coupled as shown by the rod T, with the slide-rest P, and the long arm whereof carries a weight U, which acts to maintain a roller P^1, mounted upon the said slide-rest against the edge-cam R, the said roller P^1 being of sufficient length to allow the slide-rest to make its full longitudinal traverse without leaving the said cam.

The lathe is so arranged that it will be automatically stopped at each revolution of the cam-shaft D, and that it can likewise be arrested at any moment when desired by the operator in charge. To effect the first, or the automatic

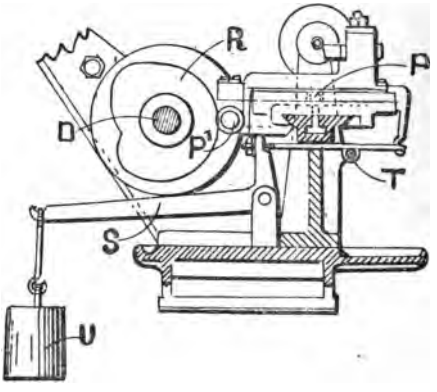

FIG. 272.—Self-acting Hub-turning Lathe (part Transverse Section).

stop motion, a disc V, having a peripheral notch V^1, is mounted upon the extremity of the cam-shaft D, as shown upon the right hand side of Fig. 271. The lever for operating the clutch C is provided with a movable stop or projection W^1, which extends at both sides of the said lever, and the lower extension of this stop is normally kept in contact with the side of the disc V by a spiral spring X, connected to the clutch lever, so as to maintain the clutch C in action and the driving pulley B in gear with the shaft A. Upon the said notch in the periphery of the disc V, however, coming opposite the projection upon the lever W, it is forced into it under the action of the spring X, and the

clutch C is thrown out of action through the other end of the lever W, which engages with a sliding sleeve, working the clutch mechanism, whereupon the pulley B is disengaged from the shaft A, and rotates freely thereon. To admit of the machine being stopped at any moment, a short lever Y is pivoted at Y^1 to the striking or clutch operating lever, one extremity of which short lever Y is connected by a fork to the upper projecting end of the stop or projection W^1, and is normally held in such a position by a suitable spring Y^2, as to retain the latter in its lowermost position, and in contact with the side of the disc V. When therefore it is desired to arrest the machine, all that it is necessary to do is to depress the free end of the short lever Y, and raise the stop W^1 above the edge of the disc V, when the spring X will move the clutch lever as before, and throw the clutch C out of action.

The headstock spindle is hollow, and its front end is coned and slit into jaws which can be brought together by an internally coned and screw-threaded socket. An adjusting screw is provided in the back of the hollow spindle, which screw engages in an internally screw-threaded inner hollow spindle, and is operated in the usual way through a suitable hand wheel. To place a bicycle hub in position between the lathe centres, a driving plate is screwed on to the front end of the inner hollow spindle, and a steel centre-pin upon which the hub is mounted enters the end of the said hollow spindle. The carrier which holds the part by means of screws is formed of two diameters internally, one for receiving the flange of the hub before turning, and the second to receive the finished part. Both longitudinal adjustment, and likewise small adjustments of the carrier for slight disparities in the diameter of the work, can be effected.

Two forms of lathes will be found described and illustrated in the next chapter, wherein the subject of repairs and renewals will be dealt with.

The power-lathe shown in Fig. 299 would be found a useful type in any cycle works; that represented in Fig. 300 is a foot-lathe suitable for small shops.

A very useful little tool has been patented by C. T. Austen, No. 10,572 of 1895, by which the nipples of the

wheel can be screwed up much more expeditiously than can be done in the ordinary manner. In an improved form of the apparatus power can be used and a wheel built up very rapidly, and so accurately as to require but little after adjustment.

Fig. 273 illustrates a wheel erector suitable for cycle factories.

Fig. 274 shows a factory inflator mounted on wrought-iron stand, which apparatus is made, and has been provisionally protected, by the Cycle Components Manufacturing Co. Limited.

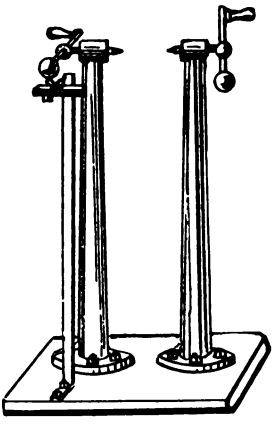

FIG. 273.—Wheel Erector.

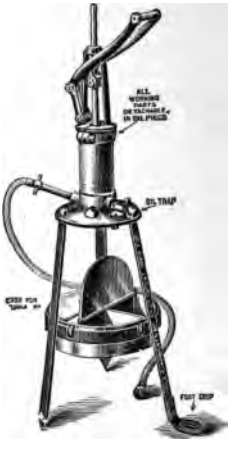

FIG. 274.—Factory Inflator.

DRIVING GEAR.—An important feature in modern rear-driving safeties in which chain gear is employed, is the proper construction of the chain or sprocket wheels, as it will be readily understood that strength, lightness, and easy running, which is a desideratum in all cases, in that under consideration is an absolute necessity to enable a high efficiency to be attained.

The chain or sprocket wheels for pitch chains are made in many different forms, plain castings or stampings being of

course the most common, and various types have been already illustrated and described.*

For machining the teeth and other parts of these wheels, some form of milling machine is the most useful tool. At the works of the Premier Cycle Company Limited, the sprocket or chain wheels are of a built-up type, the toothed rim consisting of a separate stamping or steel casting, and

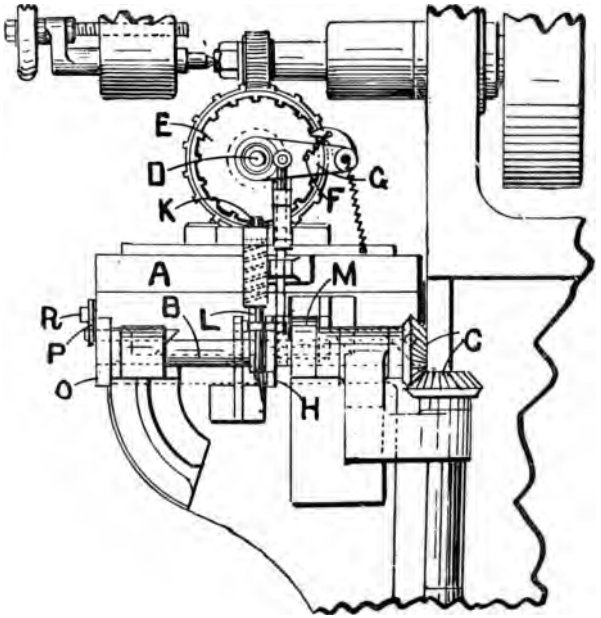

FIG. 275.—Special Milling Machine for Cutting Sprocket Wheels (part Side Elevation).

the arms being riveted to lugs or projections formed upon the inner surface of the first-named part, the hub is composed of a large washer riveted to one side, and of a flange upon the crank-axle upon the other. In the works mentioned milling machines of special construction are used for machining the toothed rims of these wheels. One of

* See chapter on Component Parts, pages 163-194.

these machines is illustrated in side and front elevation in Figs. 275 and 276. A is the bed upon which the work is to be rotatably supported. By means of an automatic arrangement this bed A can be traversed past the milling tool in one direction, whilst a spindle upon which the said work is fixed receives an intermittent or step-by-step rotary motion, remaining stationary during the period for which the milling tool is operating; the travelling bed A also moves back for a fresh cut. The mechanism for effecting the above

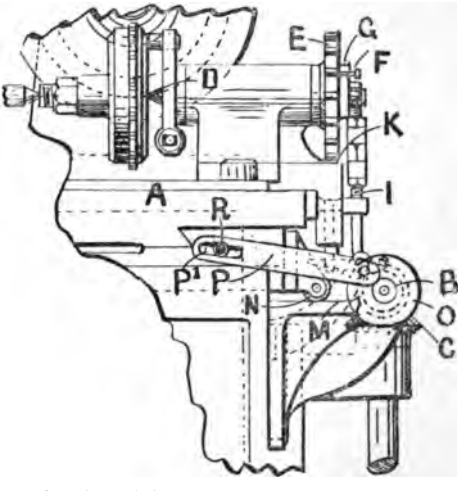

FIG. 276.—Special Milling Machine for Cutting Sprocket Wheels (part Front Elevation).

movements comprises a cam shaft B, rotatably mounted in bearings in suitable brackets secured to the front of the frame of the machine. Rotary motion is imparted to this cam shaft B, through suitable bevel gearing C, from the driving shaft of the machine. D is the spindle for carrying the work (in the illustration a toothed rim of a sprocket or chain wheel is shown centred and supported thereon), on the front extremity of which is fixed a dividing wheel E, so arranged that it will receive an intermittent or

step-by-step rotary motion through a pawl F, mounted upon the free end of a pivoted arm or lever G, which latter is actuated by a cam H, fixed upon the cam shaft B, through a rod or adjustable connection I. K is a catch which is operated or moved at the proper time by another cam L, fixed upon the cam shaft B, so as to enter one of the notches in the divided wheel E, and thus fix or lock the latter in position, and hold the object stationary whilst the milling tool is performing its work thereon. Forward motion is given to the bed A, to convey the work past the tool, by means of a third cam M, fixed upon the cam shaft B, which cam wipes against a roller N (as clearly shown in the front view, Fig. 276), and so imparts the requisite travel to the said bed. O is a disc crank likewise fixed upon the cam shaft B, this disc crank O gives the necessary reverse movement to the travelling bed A, through a link or connecting rod P, as also more clearly shown in Fig. 276. The required amount of lost motion is provided for by connecting the link or connecting rod P to the bed A, by means of a stud or pin R, working in a slot P^1, in the said link. To assist the return movement of the travelling bed A, a suitable spiral spring, not shown in the drawing, is provided.

It is absolutely essential that the axle should be perfectly true after hardening, and that the latter be quite uniform round the races for the balls, and at the same time soft or tough enough at the ends to obviate fracture from sudden shocks. Tool steel was found to be unsuitable for the purpose from its liability to crack in hardening, and to break off in use; and ordinary mild steel is objectionable, owing to the difficulty experienced in securing a uniform hardening. At present several plans are adopted, one being to form the axle of mild steel, leaving it unhardened, the cones for forming the ball races being made of tool steel, hardened by quenching, which are either screwed on, the threads being left- and right-handed, or they may be sweated in place upon the axle. Stampings are also employed, which consist of cores of iron or mild steel, with outer shells of tool steel. A third method, and the cheapest, is to make the axle from one piece of special steel, which is to some extent hardened by quenching, and which should be also very thoroughly case-hardened.

A very usual practice is to first turn up the axle roughly in an ordinary lathe, the portions forming the cones being left slightly in excess of the finished dimensions. The roughly turned axle is then subjected to the box-case hardening process, the parts required to be left soft being well plugged with clay, and the lid of the box tightly luted with a mixture of equal parts of clay and sand, and exposed in the furnace for from thirty to fifty hours.

The materials used to pack round the articles in case-hardening are usually small pieces of bone and wood charcoal, with some burnt leather.

Cycle makers, however, unfortunately frequently prefer, for cheapness, to employ the prussiate of potash process, which only hardens the surface to a very slight depth. This is performed by first heating the axle to a bright red, rubbing the surface thoroughly with powdered prussiate of potash, or with a mixture of prussiate of potash 3, to sal-ammoniac 1, reduced to powder, allowing to cool to a dull red, and quenching in water. A repetition of the operation slightly deepens the hardening.

The axle will after this hardening process be found to be more or less twisted and out of truth, which must, if necessary, be remedied by hammering. After which it may be placed between the centres of the emery grinding machine, wherein it is slowly revolved, whilst an emery wheel, mounted in a slide rest, and rotated at a high rate of speed, is traversed along the parallel portion between the cones or races, which latter are ground to the proper sweep by the sides of the emery wheel. The amount ground off the spindle, and consequently the diameter thereof and the distance apart between the races, is regulated by stops, so that the axles are all finished dead true after they have been hardened to exactly uniform dimensions.

In Fig. 277 is shown a handy lathe attachment made by L. Sterne & Co. Limited. It is so constructed as to fit on the slide rest of an ordinary lathe, and may be used for grinding the axles or spindles after case-hardening, and also for other purposes. The emery wheel can be attached to either end of the spindle.

The discs or screwed cups which, with the balls, complete the bearings may consist of stampings, which being almost

of the exact dimensions, require but little machining, although, on the other hand, a considerable amount of time will be occupied in chucking and re-chucking them. They are also sometimes turned from solid bars of mild steel and case-hardened. The first method is much used, as being the cheapest, but the second produces the best and most accurate work. Several kinds of steel, including high carbon tool steels, if tempered with great care, may be used.

The machining may be very satisfactorily effected in an automatic capstan lathe, having a traversing cut-off rest and chasing-bar, a hollow mandrel, and a wire feed. In this machine the tools can be brought into operation, one after

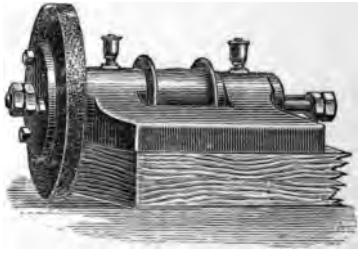

FIG. 277.—Lathe Attachment for Emery Grinding.

the other, so as to successively perform the following operations, viz. :—First, the boring of the centre hole ; second, the first cut or roughing out of the ball race ; third, the second cut or regulation of the depth and shaping of the latter ; and fourth, the finishing cut to complete the sweep, and to face off the fore lip. Whilst these operations are being performed, the thread will have been cut by the chasing-bar, and the cut-off rest has been proceeding to bring the disc down to the desired thickness. The disc should be next hardened, and it can then be chucked by its screw-thread rotated in one direction, and the ball race ground true by means of an emery grinder having a wheel of the exact shape required rotating at a high speed in the opposite direction.

ENAMELLING.

The enamelling and finishing of the framework of cycles may be effected in various ways. It is an operation requiring considerable care and skill, and perfection can only be attained by long practice. The following are some of the points to be attended to in order to attain satisfactory results.

To ensure success the enamel should not be applied with a brush. The usual temperatures at which to stove enamels are from 300° to 380° Fahr., and the surface may be prepared and smoothed for finishing by polishing with powdered pumice stone and rottenstone, or other suitable materials.

The finish may consist either of a thin coat of fine grade finish-enamel or of clear varnish. With the hydrocarbon processes (which are trade secrets), an oil finish is usually employed.

To japan a metallic surface, coloured varnish, known as japan, must be laid on in a thick coat, and be then thoroughly dried by stoving the article at a temperature of about 300° Fahr., which causes the whole of the solvents or vehicle of the gums or resins of the japan to be quickly driven off or evaporate, wherewith the gummy residue will become liquified or semi-liquified, and readily adapt itself to all inequalities of the surface, and firmly adhere to the metal. The operation may be repeated until the desired colour and the requisite hardness and finish has been attained.

A good double-cased gas-heated enamelling stove or oven is shown in Fig. 278. These ovens are made in sizes varying from 6 ft. in height, 4 ft. in width, and 3 ft. in depth, to 6 ft. in height, 9 ft. in width, and 6 feet in depth. For cream and other light-coloured enamels the stove or oven should be so arranged that the gases will not come in contact with the work, thereby avoiding the discoloration thereof from soot.

The process of drying out and fusion by subjecting to heat effects a firm contact and a strong adhesion of the gums or resins to the surface to be treated, augmenting the density of the coat or layer, and enabling it to resist wear, and keep a glossy surface for a longer period. If a coat or

layer of sufficient thickness be applied, a fine uniform lasting glossy surface will be presented on cooling.

The following practical hints upon japanning, taken from the *Scientific American*, will be of interest:—

"In practice," says this authority, "the work to be japanned is first thoroughly cleansed and dried. If of wood, composition, or other porous material, it is given, while warm, several coats of wood filler, or whiting mixed up with a rather thin glue size, and is, when this is hardened, rubbed down smooth with pumice-stone. It is then ready for japan

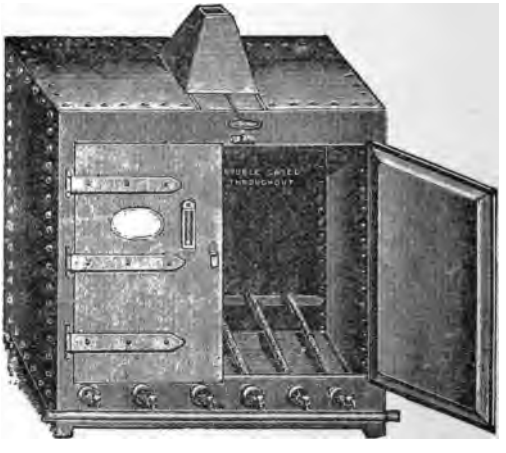

FIG. 278.—Double-cased Enamelling Stove or Oven.

grounds. Metals, as a rule, require no special preparation, receiving the grounds directly on the clean dry surface.

"In japanning, wood and similar substances require a much lower degree of heat, and usually a longer exposure in the oven than metals, and again a higher temperature may be advantageously employed when the japan is dark than when light-coloured grounds are used, so that a definite knowledge of just how much heat can be safely applied, and how long an exposure is required with different sub-

stances and different grounds, can only be acquired by practical experience.

"The japanner's oven is usually a room or large box constructed of sheet metal, and heated by stove drums or flues, so that the temperature—which is indicated by a thermometer or pyrometer hung up inside, or with its stem passing through the side wall midway between the top and bottom of the chamber—can be regularly regulated by dampers. The ovens are also provided with a chimney to carry off the vapours derived from the drying varnish, a small door through which the work can be entered and removed, and wire shelves and hooks for its support in the chamber. The ovens must be kept perfectly free from dust, smoke, and moisture.

"A good cheap priming varnish for work to be japanned consists of—

Shellac (pale)	2 oz.
Resin (pale)	2 oz.
Rectified spirit	1 pint.

Two or three coats of this is put on the work in a warm dry room. A good black ground is prepared by grinding fine ivory black with a sufficient quantity of alcoholic shellac varnish on a stone slab with a muller until a perfectly smooth black varnish is obtained. If other colours are required, the clear varnish is mixed and ground with the proper quantity of suitable pigments in a similar manner. For red, vermilion or Indian red; green, chrome green or Prussian blue, chrome yellow; blue, Prussian blue, ultramarine, or indigo; yellow, chrome yellow, &c. But black is the hue commonly required. The following are good common black grounds:—

Asphaltum	1 lb.
Balsam of capivi	1 lb.
Oil of turpentine	q.s.

The asphaltum is melted over a fire, and the balsam, previously heated, is mixed in with it. The mixture is then removed from the fire, and mixed with the turpentine.

"Moisten good lampblack with oil of turpentine, and grind it very fine with a muller on a stone plate. Then

add a sufficient quantity of ordinary copal varnish, and rub well together.

Asphaltum	3 oz.
Boiled oil	¼ quarts.
Burnt umber	8 oz.
Oil of turpentine	q.s.

Melt the asphaltum, stir the oil, previously heated, then the amber, and when cooling thin down with the oil of turpentine.

"An extra fine black is prepared from—

Amber	12 oz.
Asphaltum (purified)	2 oz.
Boiled oil	½ pint.
Resin	1 oz.
Oil of turpentine	16 oz.

Fuse the gum and resin and asphaltum, add the hot oil, stir well together, and when cooling add the turpentine.

"A white ground is prepared from copal varnish and zinc white or starch. Large japanners seldom make their own varnishes, as they can procure them more cheaply from the varnish maker.

"From one to six or more coats of varnish are applied to work in japanning, each coat being hardened in the oven before the next is put on. The last coat in coloured work is usually of clear varnish, without colouring matters, and is in fine work sometimes finished with rotten-stone and chamois. For ordinary work the gloss developed in the oven under favourable conditions is sufficient."

NICKEL-PLATING.

This process plays a very important part in the manufacture of cycles. The deposition may be effected either by battery power or by dynamo-electricity, the former being far inferior to the latter, and failing to produce the pure white colour of the metal which is the chief beauty of the deposit.

POLISHING.—The preparatory treatment of the work before nickel-plating comprises polishing, it being found advisable to have all the parts required to be bright

thoroughly polished before carrying out the above process. This operation requires polishing and scratch brushing lathes or spindles, and buffs, bobs, and dollies or mops.

A polishing and buffing lathe made by Sterne & Co. Limited is shown in Fig. 279, the construction of which machine will be very readily understood from the illustration.

The buffs, bobs, mops, or dollies, &c., can be mounted in the lathe as required by screwing them upon the screw-threaded ends of the lathe spindle or mandrel. The first consist of bull neck leather, or of walrus, or sea horse hide, &c., cut to certain standard sizes. Bobs are simply discs of wood having a peripheral band or strip of buff leather secured by cement or glue. The dollies or mops, which are only varieties of buffs, consist of a number of circular pieces of coarse calico held or clamped between metal or other

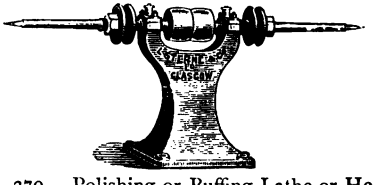

FIG. 279.—Polishing or Buffing Lathe or Head.

discs which are screwed, bolted, or otherwise firmly secured together, central holes being formed therein and in the calico to admit the lathe spindle or mandrel.

Sheffield lime and oil, rottenstone, oil, &c., are employed with the buffs, Trent sand, glass cutters' sand, &c., with the bobs. The dollies are used for finishing brass and copper work. Taking a steel article as an example, it should be first ground on an emery wheel, or with a bob, then buffed with glass cutters' sand first, and subsequently with Trent and other finer sands. Brass and copper work should receive a higher polish by subjecting it to the action of a dolly with dry lime. It is well to bear in mind that this preliminary polishing before the nickel-plating process, enables a fine lustre to be subsequently obtained with comparatively little labour in subsequent polishing, and is in fact essential to ensure first-class results.

BATHS.—These consist of the potash, the cyanide, and the hydrochloric or muriatic acid baths or dips.

The first of these baths or dips has to be used hot, consequently the tank, which may be of iron, should be fitted with steam coils, or other means for heating the solution. The solution should consist of American potash in the proportion of about one pound to each gallon of water.

The cyanide bath or dip is used for the removal of any oxide that may have formed on brass or copper surfaces after cleaning, or whilst the articles were being scoured. The solution should consist of half a pound of cyanide of potassium to each gallon of water, and the vessel must be made of wood.

The last, or the hydrochloric or muriatic acid bath or dip is employed to remove any slight traces of oxidation from steel or iron surfaces after scouring. The hydrochloric acid should be used in the strength of about one part of acid to five parts of water by measure, and should be placed in a wooden vessel lined with pitch or lead.

THE PLATING TANK OR VAT.—This should be of sufficient dimensions to hold about 15 per cent. more solution than the quantity intended to be worked. It should be constructed of wood, and lined first with pure sheet lead having burned not soldered joints, and secondly with an inner lining of match boarding. The solution should preferably be made by dissolving in hot water, pure double sulphate of nickel and ammonia crystals in the proportion of one pound to each gallon of water. The double chloride of nickel and ammonium may also be employed, but the first-mentioned salt is that most commonly used, and is in every way the most desirable for the purpose. The nickel anodes for the bath should be suspended at a distance of three inches apart, from edge to edge on each side of the said bath, by means of copper hooks from the positive conducting rods, which latter are usually either formed of brass tubing with an iron core, or of solid copper.

ELECTRIC CURRENT.—As already mentioned, this may be produced either by battery power, or by means of a dynamo-electrical machine.

If the first be employed, a battery of high intensity should be used, one of low intensity never producing

satisfactory results. The most suitable batteries for the purpose are as follows: — For the electro-deposition of copper, &c., Daniell, Calland, Smee, chromate of lime, Bunsen, bichromate of potash carbon. For the electro-deposition of nickel and silvering, Daniell, Slater, bichromate of potash, chromate of lime.

A 45-gallon nickel bath would require four double carbon batteries, and it should be borne in mind that it is always better in every way to have a considerable surplus of power at command.

Wherever any considerable quantities of articles are required to be nickel-plated, dynamo-electricity should be employed, as the consumption of zinc, acids, &c., form serious items in the expense of electro-plating by battery power, whilst the former, especially where power is already used for other purposes, enables the necessary current to be produced at a comparatively low cost. When a dynamo electric machine is used, suitable resistance coils must be employed, so as to enable the current generated to be controlled, in accordance with the size of the article, or with the number of the articles in the bath, and so regulate it that a small article may not receive the electro-deposition too quickly.

The dynamo-electric machines for larger installations may be capable of depositing from 20 ozs. up to 50 lbs. or more per hour, and the horse-power required for driving will vary from $\frac{3}{4}$ horse-power up to 4 horse-power or more. The most useful size for general work is perhaps one capable of depositing about 50 ozs. of metal per hour, and requiring about $1\frac{1}{2}$ horse-power.

A dynamo-electric machine especially adapted for electro-plating is made by William Elmore Limited. These machines will deposit from 20 ozs. up to 50 lbs. of metal per hour, and are claimed to possess the following good qualities: —No reversal of current. No mercury or other governor to get out of order. Never become hot. Require no water. Are perfectly automatic. And require no special knowledge to work.

PRELIMINARY PREPARATION.—The polished article previous to being placed in the plating tank or vat, must be subjected to a preliminary preparation. This consists in immersing it for a short time in the hot potash bath, then

rinsing it, next, if of brass or copper, dipping it into the cyanide bath or dip, rinsing, and finally removing it to the scouring bench or tray, which latter usually consists of a watertight shallow wooden trough or tray mounted upon convenient tressels. To support the work, a shelf is fixed across the trough close to its upper edge, and it is desirable to cover the upper surface of the cleaning board with buff leather, or other suitable material to prevent the scratching or marking of the article being scoured. The trough or tray should always be maintained about half full of clean water, and the article under treatment should be dipped into this water after cleaning.

Great care should be exercised in the cleaning, which should be performed by a rapid application of a brush, dipped in powdered pumice-stone and water, to every part of the article, bearing in mind that should any part thereof be skipped, the nickel plating will be certain to strip or peel off thereat. To prevent the hand from coming in contact with the article, the latter should be grasped by means of a pair of wooden tongs or a piece of wet cloth, or the injurious effect may be prevented by constantly dipping the hand into disintegrated pumice-stone.

After cleaning, the article should be once more well rinsed in clean water until all the pumice powder is removed, and if it be of brass or copper, again immersed in the cyanide bath, finally rinsed, and then placed in the nickeling tank or plating vat. To ensure satisfactory results it is absolutely essential that the article should rapidly receive a slight deposit of the metal, or be what is technically known as "struck." The remainder of the coating may be then deposited more slowly. It is advisable therefore to arrange the bath with this object in view, the power being reduced after the lapse of a certain time, and the said reduction continued until the desired deposit is obtained.

TREATMENT OF DIFFERENT METALS.—Cast-iron is susceptible of receiving a coat of nickel with great facility if the preliminary treatment of the article has been carefully attended to. The article upon removal from the potash bath, after rinsing, must be immersed in a pickle of dilute sulphuric acid, in the proportion of one of acid to ten of water, for from half to one hour, or for a sufficient time, to

soften or break up the black oxide on the surface; again rinsed and thoroughly scoured with silver sand and water and a very stiff brush. Any sand holes or defects in the casting should next be made good, the article again brushed over, momentarily immersed in the hydrochloric or muriatic acid dip or bath, finally rinsed, and passed to the nickel-plating tank or vat. Steel must also be dipped in the hydrochloric acid bath, and in this, as in the previous case, the complete removal of all oxide from the surface of the work is essential, as the nickel solution has not the slightest solvent power upon oxide.

It is highly desirable in the case of steel, though not absolutely necessary, and also in the case of ordinary cast, malleable, or wrought iron, to apply a preliminary coating of copper. Not only does a deposit of nickel adhere more tenaciously to copper and brass than to iron and steel, but, furthermore, the copper coating upon the latter enables the refusal of any part of the surface, owing to defective scouring or pickling, to take the deposit, to be detected and remedied before failure in the nickel-plating vat, which latter frequently entails most disastrous results, as after repickling and rescouring the defective article, the nickel deposit, upon reinsertion into the nickel plating vat, not infrequently refuses to adhere firmly to the first deposit, and peels or strips off, necessitating a complete stripping and replating. This defect can be more readily detected, and can, moreover, be remedied with comparative facility, when coating the article with copper, by rescouring, repickling, and again coating with copper.

A hot bath of coppering solution (cyanide of copper) should be employed, and the article can be then coated in a few minutes. In the case of cast-iron the solution should be very rich in metal, and the best temperature at which to maintain the bath is one of about 130° Fahr.

In a letter to the *American Machinist*, W. S. Harris gives the following valuable hints upon the best method to adopt for the nickel-plating of small articles of brass or any other of the soft metals, which are the result of his extensive experience in this class of work :—

"If the work be new, it should be brought down to a fair surface with the file and fine grains of emery paper,

and then finished on a felt wheel with tripoli. That prepared in cakes is the best and most convenient, as it can be held against the wheel while running, and thus the wheel will be well charged without stopping the lathe. After the work has been well polished in this way, it should be cleaned in benzine or ley to remove adhering particles of tripoli and dirt. Now the final high polish may be given with the rag wheel and rouge, when the article will be in readiness for the last and most important part of the cleaning, which is done with precipitated chalk made into thick paste, with just enough ammonia water to give it a sharp smell. Now hold the articles in a pair of wooden pliers, or in any way to keep them from coming in contact with the hands, while they are well brushed over with the chalk mixture. Then they should be rinsed in running water, and if there is no part that is not covered with a film of water, they are ready to be placed in the circuit as soon as possible; but if there are spots where the water does not cover the object, the work shows imperfect cleaning, and should be gone over again as before with the chalk and rinsed. The bath should be composed of sulphate of nickel and ammonia, with pure rain or distilled water, and the strength should be 70° Beaume's hydrometer, or about 10 ounces of the salts to each gallon of water. The bath should also be kept as near neutral as possible by testing with litmus paper and adding small quantities of ammonia sulphuric acid as the case may demand. The length of time the object should remain in the bath depends on the thickness of plate wanted, and strength of battery. A weak battery and longer exposure will give the best results. If the battery be too strong, the objects will assume a rough, grey appearance."

STRIPPING AND REPLATING.—A large proportion of the plating consisting in a number of works of repairs to worn-out and damaged surfaces, the satisfactory replating of such nickeled surfaces forms an item of considerable importance in these cases.

The first operation to be performed in renickeling is to completely remove the first or old coat, as a deposit of nickel cannot be got to adhere properly to a previous layer of the same metal. For this purpose a stripping bath must be provided, containing a solution consisting of sulphuric

and nitric acids, nitrate of potash, and water, in the proportion of about 4 lbs. of the first, 1 lb. of the second, and 2 ozs. of the third, to each pint of water, or 2 parts of sulphuric acid, 1 part of nitric acid, and 2 or 3 ozs. of common salt to every pint of water. Mix the acids in a stoneware vessel, and add the water slowly. Whatever the proportions of the ingredients, however, it must be borne in mind that the nitric acid is the really active solvent in the stripping solution, and, therefore, whilst sufficient of the latter must be used to ensure the effective removal of the old deposit, due care must be taken to see that the proportion thereof is not so increased as to cause injury to the metal underneath.

To use the stripping bath first immerse the article suspended on copper wire in boiling water, and whilst heated from this immersion, plunge it into the stripping solution for thirty seconds; then examine the article, and should the metal show at all through the plating, cautiously continue the operation until the whole of the latter is removed, taking care, upon each occasion that the article is removed from the stripping bath for inspection, to dip it into a receptacle containing cold water. The stripping bath must be located either in the open air, or, if situated in an enclosed place, in close proximity to some flue where there is a good draught, so that the fumes arising from the said bath may be carried off harmlessly.

The next thing to be done after stripping is to thoroughly rinse the work, first in cold and subsequently in hot water, dry, and polish, as already described with reference to new work. After which it may be inserted into the nickel-plating tank or vat, and a layer or coat of nickel deposited thereon as before, when, if the stripping, &c., has been properly carried out, the work will look like new.

General Observations.—The nickeling solution not readily dissolving the anodes, the surface of the latter exposed to its action must greatly exceed that of the articles to be nickeled, which are placed in the bath, as otherwise the deposit thereon will be very irregular, and also of a poor colour. The solution used in the bath, moreover, being possessed of but slight electrical conductivity, it is important to pay particular attention to the distribution of

the anodes, which latter should be placed opposite each side or surrounding the article to be treated, so as to thus avoid the deposit taking place chiefly upon such side of the article as might be placed opposite the said anodes. The anodes should also be of ample length, in accordance with the depth of the bath. If too short, the lower parts of an article placed in the latter will not receive the same amount of deposit as the upper. It is of the utmost importance in nickel-plating to employ none but the purest materials.

Polished nickel surfaces are not liable to be tarnished by sulphide of hydrogen, or by oxygen, but they become dulled by a humid atmosphere. To obviate this, nickel surfaces should be carefully wiped every day. Steel articles such as cycles should invariably be thoroughly wiped dry before being put on one side, and it should be remembered that no matter how well plated a cycle may be, if the cleaning off of wet mud be neglected until a succeeding day, rust will surely make its appearance. For cycles paraffin oil is about the best material to apply after cleansing, as it has the effect of protecting nickeled surfaces from the humidity of the atmosphere.

CHAPTER IX.

Repairs and Renewals.

THE subject of repairs is one intimately connected with the manufacture or construction of cycles. The same tools are to a considerable extent required, although in shops where repairs only are executed many makeshifts and substitutes are usually employed with more or less success. Indeed, it may here be remarked that with cycles, as in the case of other machinery, the efficient accomplishment of most repairs of any magnitude is almost entirely dependent upon the ability and ingenuity of the workman to cope with and overcome the difficulties as they arise, no fixed rule of procedure being possible.

Repairs to cycles may be briefly classified under four separate headings, viz. :—Those necessitated by injuries to the frame; those required by reason of accident to, or of wear and tear of, the wheels; those rendered desirable for similar reasons with respect to the bearings and driving gear; and finally, such as arise from the deflation or partial deflation of the tyres through punctures or from other causes.

Frames, &c.

A considerable number of the repair jobs to the framework of cycles will entail the resetting or readjustment of frames, twisting of the latter being the usual accompaniment or outcome of a fall, accompanied by any degree of violence, or a collision, and being even frequently occasioned by the chain mounting upon the teeth of either of the chain or sprocket wheels. In cases where any of the tubes are

badly injured, new members may have to be inserted in their places, or the damaged parts may be sufficiently strengthened with bushes or liners. When the frame is twisted or out of alignment, the fault will have first to be located, and the bent portion brought over.

Fig. 280 illustrates a handy form of erecting or cleaning stand. Fig. 281 is a simple form of tube clamp, which should be fitted with a lining of indiarubber so as to avoid damage to the tubes. Fig. 282 shows an automatic adjustable tube

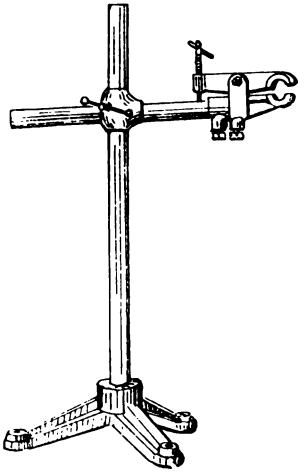

FIG. 280.—Erecting Stand.

FIG. 281.—Simple Form of Tube Clamp.

clamp, which will hold any sized tube from $\frac{3}{8}$ inch to $1\frac{1}{4}$ inch without damaging its shape. It will also hold oval fork sides without permitting them to slip or twist, and a frame can be held at any angle while fitting or filing. It is likewise useful for making lapped joints for handle-bars, seat-pillars, &c. All of these tools would be found very handy in a repair shop.

It is a mistake to remove a dented tube from a frame and to replace the same after removing the bulge by passing a drift or a mandrel down it and hammering. The

chief trouble and expense entailed in the operation is the removal or melting out, and rebrazing of the tube in the sockets. The value of the tube itself, especially after the expenditure of labour thereon in removing the bulge or dent, is trifling. It is evidently advisable therefore in all cases, unless it should happen to be absolutely unprocurable, or where the open ends of the bulged tube admit of the use of a drift or mandrel without removal, to insert a new length.

Another point which should be particularly attended to is not to repair any fracture in a tube by means of a bush or liner at any distance from a socket. To effect a repair of this description the damaged end of the tube should be first cut

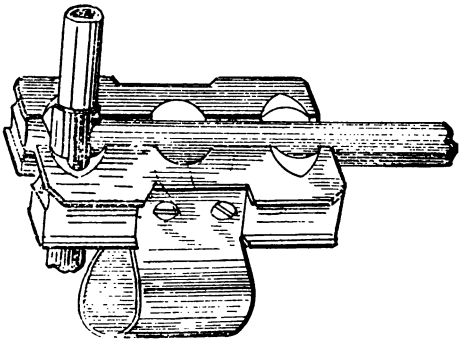

FIG. 282.—Automatic Adjustable Tube Clamp.

away, and a bush or liner formed from a piece of tube of the same external diameter as the tube to be repaired, and of a gauge of sufficient thickness to admit of a suitable portion being turned down to enter the latter. Or instead of the above, a piece of tube of such diameter as to telescope into the tube to be repaired may be brazed into it, and the thickness of the projecting portion made up by brazing another piece of tube upon it. This bush or liner, when neatly brazed into the tube end, forms a good enough job, and being cut off to the right length, can be brazed into the socket as before. When inserting bushes, it must always be borne in mind that, as the tube is weakened at each heating, they should be carried for a considerable distance

into the old tubes in order to secure a strong joint. A repair of this description has frequently to be effected to the inner socket tube connecting the crown of the steering wheel fork to the handle-bar. The reasons for the numerous failures of this part may be traced to two principal causes. Firstly, the severe and constant vibration to which the metal is subjected when the cycle is in use, gradually destroying the homogeneity of the metal, causing granulation thereof, and the formation of a line of weakness at that point where the greatest resistance is experienced. Secondly, the use of a tube of too thin a gauge, and therefore of insufficient strength to withstand the great strains put upon it by the handle-bar. Owing to the above reasons, this particular tube frequently gives out, the usual point of fracture being in close proximity to the lower ball race. An additional inducement to the operator to effect this repair by means of a bush, as above described, is found in the desire to save the fine thread at the end of this tube, which is very difficult to cut. In melting out the broken end of tube from the crown piece it is necessary to take precautions not to damage the joints of the fork.

Neither the insertion of a long bush of thick tube, fitting into the inner socket tube, nor of a solid turned plug of iron or steel, should ever be attempted if a good job is desired. The first is objectionable on account of the impossibility of securing a sound brazed joint of such a length, and the liability to melt off the fork and crown piece in the attempt to perform the operation. The second is undesirable by reason of the considerable accession of weight caused by the solid mass of metal; by the almost certainty of the tube being ruined by burning when brazing, owing to the overheating thereof when raising the solid plug to the required temperature; and finally, by the point of greatest resistance, and consequently also the line of weakness, being shifted farther up the tube. Wherever a tube is so damaged as to render its removal and replacement by another one necessary, great care must be exercised in doing so to avoid damaging the mouth of the socket. Should, however, the socket be accidentally cracked, a mandrel will have to be inserted, and the latter brought to shape, and the crack brazed. This repair, however, is only

admissible in cases where the crack is of small dimensions, and does not extend throughout the entire length of the socket.

To remove a damaged tube, the pins passing through the sockets and tube ends having been first drilled carefully out, it will be found a good plan to cut the said tube through close to the socket at each end, and to remove the central part. By cutting away the central portion of the tube, the removal of the sockets can be readily effected without bending the down tubes to which they are attached, or causing any injury to the said sockets themselves, and, moreover as the joints at each end of the frame need not be heated at the same time, the operation can be effected without the aid of a special brazing hearth. A further advantage is that the remaining portions of the tube can be removed much easier and cleaner by twisting them out, than by knocking them out. The alignment of the frame, moreover, will in no way be disturbed by the operation.

The framework of safeties is liable to have the alignment of the wheels thrown out by falls or collisions to an extent frequently enough to destroy the perfect steering of the machine, whilst at the same time such twisting of the frame may be imperceptible to the eye. If the tube is but slightly bent, as soon as the fault can be located—not always an easy matter—the part may be gently heated by means of a gas jet, and the defect remedied by straightening the tube in the usual manner, without even disturbing the enamelling.

If any doubt exists as to the precise position of the bend, straight edges and lines should be used to locate it, the wheels and crank axle being removed, and the above used as in building up a new frame.

When the fault has been exactly found, the straightening of the bent tube can be effected, when open at both extremities, by passing a mandrel down it, which latter should be of mild steel, and an easy fit, the end being hardened, and well rounded to avoid all possible danger of cutting the tube. When a closed member is in question it is a much more difficult task to remove a bend, and great care must be taken not to pull it over too much the other way, and so bulge the tube. The bent part should be heated, confining the heat as much as possible to the part affected,

and the tube should be supported at one side of the bend, hardwood clips, such as shown in Fig. 281, being employed to prevent any injury to the said tube by the jaws of the vice. Another clip fixed or clamped in any suitable manner at the other side of the bend, and a lever connected to the second clip, will admit of the straightening being effected in most cases.

If the blocks shown in Figs. 281 and 282 are not employed, there will be a great danger of flattening or bulging the tube by the jaws of the vice, unless they be of very stout gauge, and where the ends of the tubes are closed this fault cannot be remedied by passing a round-nosed drift, or a mandrel down the bore. If the indentations thus caused are slight, the defect may be remedied to a certain extent by running some hard solder into the hollow and filing up to the configuration of the rest of the tube, but in bad cases the tube must be condemned and replaced.

The rear fork legs of a cycle are particularly liable to become bent, and are indeed the weakest and most defective part of the framework, especially in machines of older patterns, in which they are usually of absurdly small diameter and gauge for the strains which they are called upon to support.

These fork legs may be thrown out of line from a heavy side fall, collision, or from the driving or pitch chain riding upon the chain wheels, &c. The fault can be readily detected by applying a long straight-edge to each side of the driving wheel, in the same direction as the steering wheel, when the two wheels will be found to be out of track in cases where the fork legs are bent. It is obvious, of course, that if all the parts be true, the straight-edge should come in contact with the two wheels at each side, whilst the tyres are in perfectly central positions between the forks.

To bring back these bent fork legs to their proper position, it will be necessary to remove the driving axle, chain wheel, and other parts, from the bottom bracket, so as to admit of the frame being firmly gripped in the vice by the ends of the said bracket, at the same time the driving wheel must be also removed from the fork ends, and the axle replaced in position. The tubes must then be heated near the crown of the fork, and bent or pulled over to that

side at which the largest space was found in the test to exist between the fork leg and tyre. A line taken round the bottom of the steering socket from the end of one fork leg to the end of the other fork leg, and pulled tight, should give the same distance between it and the seat stalk at each side, and the straightening operation must be continued until such is found to be the case. This latter test is, of course, only practicable in cases where the seat stalk is in exactly the same vertical plane as the two wheels of the cycle.

The removal of damaged tubes and their replacement by new ones entails the melting off of brazed joints and the cleaning up of the sockets to receive the new tube, and unless great care be exercised errors may be caused, the rectification of which would cost more than the old frame is worth. Especial caution is needed in this respect, when inserting a new top tube, in replacing the seat-clip socket upon the up tube or seat stalk in exactly the same position, otherwise the back stays will be thrown out and the wheel placed skew in the frame. The up tube, also, being usually of very thin gauge, it is quite possible to cut it almost, if not in parts, entirely away, in carrying out the necessary cleaning up for the rebrazing on to it of the seat-clip socket which was melted off, and in the filing and scraping up required after brazing, and preliminary to enamelling.

A description of joint not infrequently required is a lap-joint for connecting the handle-bar to the fork stem, and for other parts of cycle frames. These joints are either of the class known as open or bell-mouthed lap joints, or closed lap or scarf joints. The former joint is the most difficult to perform in a satisfactory manner in a repair shop. In a large factory the formation of the lap is carried out by annealing the tube and working it in presses cold; in a small repair shop, however, the operation has to be effected hot, and there is great danger of burning the metal and producing brittleness, which will result in the tube splitting. The operation is usually effected as follows:—A convenient length of tube of the proper gauge (14, 15, or 16 gauge) is heated, at the extremity, at the part to be worked only, to a dull red, and the said end driven on the horn of the anvil, or any suitable substitute. The tube must be heated frequently

and the drawing performed a little at a time, great care being exercised at each heating. It will require two heats to obtain the requisite amount of bell-mouth or flaring end, and the tube should be driven upon the point by gentle blows from a medium-sized hammer; it will be sufficient to spread the end to a depth of $\frac{3}{4}$-inch, but great caution must be used to obviate the formation of a shallow lip. The bell-mouth being produced, the next step is to bring it perfectly square with the stem, after which the flange may be formed upon the anvil face, the greatest difficulty at this latter stage being to prevent the edges from curling up, and as it is also at this time that the greatest danger from splitting arises,

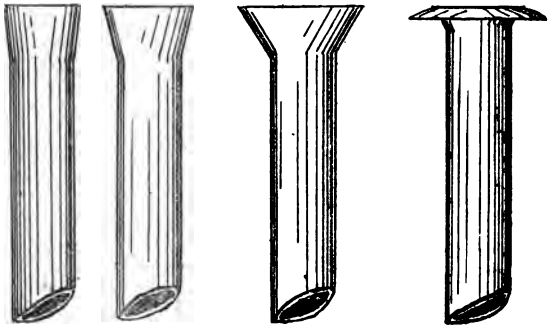

FIG. 283. FIG. 284. FIG. 285. FIG. 286.

Method of Forming Open or Bell-Mouthed Lap-Joints.

reheating will have to be more frequently resorted to; it will also be necessary occasionally to quench the tube up the part that is being worked. Figs. 283, 284, 285, and 286 illustrate roughly the principal stages of the operation. In Figs. 283 and 284, the bell-mouth is formed to a sufficient depth. In Fig. 285, the mouth is formed wider or more flaring and trued up relatively to the stem. And in Fig. 286, the flange is worked out on the anvil face. When the flange, as shown in Fig. 286, has been produced, all that is necessary in order to prepare it for brazing to the part or tube to which it is to be connected, is to hammer it over a mandrel of the exact diameter of the said tube.

To form a closed lap or scarf joint a cut must be made at each side of the end of the tube, exactly opposite to each other, and of a length equal to that of the lap required, which should be slightly more than half the circumference of the tube to be lapped; this first stage of the operation is illustrated in Fig. 287. The next step is to open or spread the split ends of the tube to a certain extent by means of a taper mandrel, as shown in Fig. 288. The joint is finally finished by heating the split ends of the tube and further spreading, and hammering them to the required shape upon a mandrel of the same diameter as the tube to which the part is to be jointed, as shown in Fig. 289. When making a

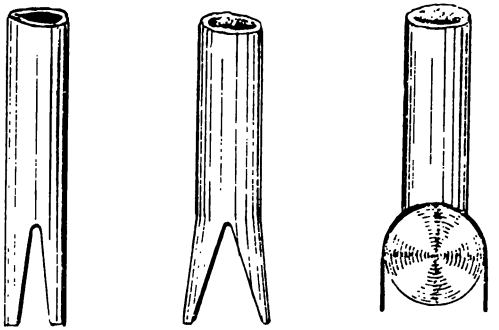

FIG. 287. FIG. 288. FIG. 289.

Method of Forming Closed Lap or Scarf-Joint.

joint of this description it is well to pin the flange in position, and the pin holes may be drilled slightly in advance of the circles scribed through the holes drilled in the flange, so as to allow for stretch, and make sure of a tight lap. The flange should fit tightly round the tube to which it is to be brazed, and the edges be brought evenly down by means of a blunt chisel or other suitable tool; if absolutely necessary, packing of sheet tin must be inserted to take up any slackness, but its use is highly undesirable and is detrimental to good work.

In Fig. 290 is shown a handy little drilling jig, by the use of which holes can be drilled without centring in frames

before brazing, and for making straight holes for pinnings. It fixes lapped work firmly together, and prevents shifting while being drilled. The tool can be either used by hand, lathe, or drilling machine. Another advantage about this little tool is that it ensures the production of straight work, and saves the breakage of drills.

Many repairs will necessitate the employment of joints of the above description, amongst which may be mentioned the repairing of a handle-bar, broken at or near its centre, which latter may be joined by pinning and brazing in a short length of tube, and uniting the stem to it by a scarfed joint, and thus covering the joints in the handle-bar. When

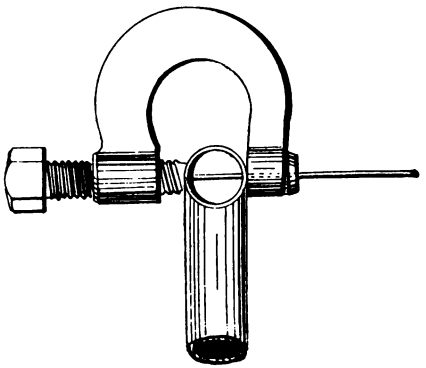

FIG. 290.—Drilling Jig.

joining a handle-bar so broken, it is obvious that it will be necessary to cut a sufficient length off one part to bring them to equal lengths and the joint perfectly central. A handle-bar repaired in this manner will, if the work has been properly carried out, be considerably stronger than it was before.

The use of a lap or bell joint may likewise be necessitated in a case where the ball head socket or similar part has become damaged, and it is inconvenient or impossible to secure a new one. In this case, by turning up a cup for the bearing portion, a socket can be constructed with comparative facility from tubing, by using an open or bell-

mouthed joint. These joints will likewise be required in the conversion of a gentleman's into a lady's frame, for fixing the stay tube from the top of the ball-steering to the lower end of the seat stalk, which tube is used to stiffen the frame after the removal of the top tube.

The most useful sizes of tubes to have in stock in a repair shop are:—$1\frac{1}{8}$ inch diameter, $1\frac{1}{16}$ inch diameter, 1 inch diameter, and $\frac{7}{8}$ inch diameter, by 16 gauge; $\frac{15}{16}$ inch diameter, and $\frac{3}{4}$ inch diameter, by 15 gauge. The latter size is that most usually employed for the handle-bar and other parts of old patterns. $\frac{7}{8}$ inch diameter tube by 16 gauge is the size almost universally used for the handle-bar stems in modern machines. $\frac{15}{16}$ inch diameter by 15 gauge tube is that most usually employed for the seat pillar down stem or stalk.

The advantage of many of the above sizes for repair work is that they telescope into the next size above or below. The repair shop should also be well stocked with tubes of the sizes used in the standard modern cycles, and also with tubes of extra thick gauges, for turning and boring out or swaging out and expanding. Perhaps $\frac{7}{8}$ inch, 1 inch, and $1\frac{1}{8}$ inch diameter by 14 gauge would be found the handiest sizes to have by one in the long run, in the way of tubing of thick gauge. All tubing employed should be of the very best quality only, and no other should on any account be put into a cycle frame.

By the use of a handle-bar T-piece the ordinary lap joint can be dispensed with, and a stronger joint can be produced with a considerable saving of time in fitting. When the handle-bar is already bent, these T-pieces can be split and closed effectually, or the bar may be cut in two. Head lugs, ball head top lugs, ball head bottom lugs, lady's frame and head lugs, bridge pieces, stay ends, tube strengtheners, liners, or bushes, and fork strengtheners, &c. &c., will also be required at various times.

A good practical experience in the making of lapped and belted joints, and in the use of sockets or jointing pieces and bushes, is essential to success in the execution of general repair work. It is also desirable that the workman be possessed of a natural fertility of resource which will enable him to cope successfully with out-of-the-way jobs.

Indeed, there is far greater scope for ingenuity in the repair shop, where all manner of unexpected jobs will have to be tackled, often with makeshift tools and appliances, than there is in the works of a large manufacturer where everything is repetition work, and the most advantageous tools and appliances are provided for its execution in a determined manner, according to the best mechanical principles.

As cycle frames are now almost exclusively constructed of straight members, the tube-bending operations are confined practically entirely to the handle-bars. As these, however, are bent into all sorts of shapes, and are placed in a great variety of different positions to meet the requirements of individual users, in addition to the standard patterns of the principal makers, which are also being constantly altered to suit the fashion of the moment, the cycle repairer must be in a position to bend a tube for this purpose when required, and should therefore be sufficiently skilled in tube bending to be able to perform any such job in a satisfactory manner. Standard patterns of handle-bars are shown in Figs. 125 to 132.

Tubes are bent for use in cycle frames in a precisely similar manner to that adopted for other purposes. They are filled and packed with sand, or some other material which can be removed after the bending operation, so as to prevent any buckling thereof taking place, and the bending is then performed either cold by means of special tools, or hot with the aid of very primitive appliances. The cold process is undoubtedly the best, inasmuch as it hardens the tube instead of softening it, as is the case when heating is resorted to. For cold bending the tube must be filled with lead or resin, preferably the former, and the filling melted out as soon as the desired form has been attained; or Smith's (Taunton's patent) flexible steel mandrel, which is shown in Fig. 291, may be employed, which consists of a long length of flat spiral coils, spring tempered, and fitted with a ratchet arrangement by means of which it can be expanded when within the tube to be bent.

The following directions for the use of the mandrel are given by the makers:—

"Tubes not supplied soft by makers should be annealled in the parts to be bent before bending. The bending process (cold) will re-harden to the degree required.

"If the mandrel will not enter the tube when at its normal (*i.e.*, not contracted or expanded) size, the tube is too small for the mandrel; but on no account contract the mandrel to enable it to enter, as this contraction is wanted after bending to free the mandrel from the bend.

"Oil the mandrel surface, then insert it in tube, leaving about ten coils of spring outside. This acts as a safety-valve in case of over-expansion.

"Grip ratchet tube lightly in a vice or other convenient tool; set teeth out of gear, and expand the mandrel by turning handle to the right three or four revolutions (but

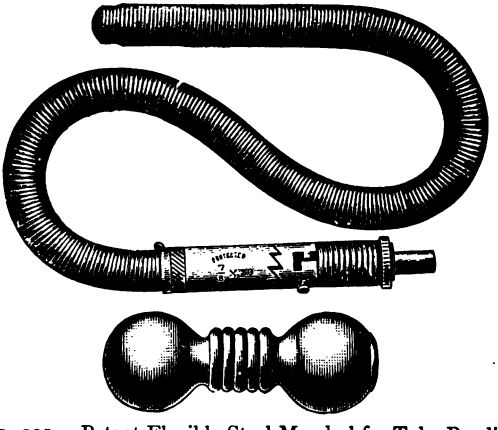

FIG. 291.—Patent Flexible Steel Mandrel for Tube Bending.

on no account exceed eight), to swell the mandrel to the inside of tube; replace teeth, and secure in that position by screwing up the milled nut. Double length mandrels may be turned double the number of revolutions.

"The tube is now ready for bending (by any ordinary method). Should any puckers arise during bending, planish same down before completing the bend, otherwise these may assume undue proportions.

"After bending, unscrew milled nut, when the mandrel will run down from its expanded form to its normal size; then contract the mandrel by turning the handle to the left, say

about five revolutions, which will generally enable the mandrel to be withdrawn. The limit of contraction is ten revolutions for single length, or twenty for double length. Do not pull out straight, but at time of pulling turn the whole mandrel round in the right-hand direction, and pull spirally. This is most important.

" Keep the ratchet teeth and socket well oiled.

" Before proceeding to bend the next tube, be careful to see that the mandrel is not left in the contracted state in which it left the previous tube."

Comparatively little skill is required for cold bending provided the proper tools be at hand, but these latter are

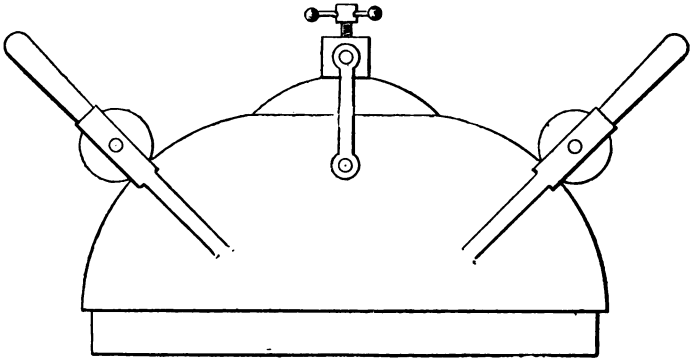

FIG. 292.—Block with Rollers for Bending Tubes.

out of the question in the case of the great majority of repair shops, and consequently they are bent hot.

The heating is, as above mentioned, objectionable because it anneals or softens the tubes; in addition to this, moreover, it forms scales, the removal of which and the necessary cleaning up weakens the tube. Hot bending requires the aid of but few tools, but on the other hand it necessitates the exertion of a considerable amount of skill, and any degree of perfection is only attainable after a lengthened experience in practical work. Where a considerable number of tubes are frequently required to be bent to one particular shape, special tools will be desirable. For the ordinary work

of a repair shop, a simple one consists of a wooden or metal block of the required shape, with two hinged arms or levers carrying hardwood or metal rollers, by means of which the tube can be worked round to the curves; and this tool as a rule will be the only apparatus needed. A clamping device of some description is provided for securing the tube at the middle of the block. Fig. 292 shows a block of this description, arranged for fixing in a vice. Tubes may be bent either hot or cold by means of this apparatus, but of course they must be all of one size, and the curvature the same; different blocks and bending rollers being required for different sizes of tubes and curvatures. A still simpler form of block is shown in Fig. 293, which consists merely of a quadrant-shaped block, having upon its upper edge a curved channel or groove to receive the tube, and of a depth equal

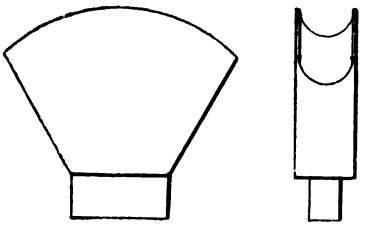

FIG. 293.—Single Tube Bending Block.

to about half the diameter of the latter. When these blocks are of wood, a liner must be inserted in the arc-shaped channel or groove to prevent burning of the material of the block.

Less skill and practice is required to bend tubes by means of blocks, but in a small repair shop the bending will usually have to be undertaken without their aid. The first operation to be performed for hot bending is to pack the tubes with the necessary filling, and unless this be done with the greatest care, failure and buckling of the tube will be the almost inevitable result, for any flats or indentations so formed on the tube can seldom or ever be completely removed. To fill the tube for hot bending, the best packing is Calais sand, of very fine grain, and thoroughly dried in an oven to eliminate all moisture. The process of filling

should be conducted slowly, and each lot inserted be well rammed down before the next supply is poured in. Either hardwood or iron or steel plugs may be used, one being of course placed in position at one end of the tube before commencing to fill in the sand. Care must be taken to see that the second plug will, when driven in, reach the core of sand, as otherwise the latter will become loose, and the work certainly be spoilt. Indeed, the ramming of the sand, so as to form a hard core, is the chief requisite for success in the operation.

In heating the tube it is necessary to confine the heat, as far as possible, to a certain predetermined locality, as the tube will bend wherever hot, and most easily, of course, where at the highest temperature. A bright red heat is required, and all attempts at bending should be stopped the instant the heat falls to a dull red. If a sharp bend is being made, a second heat will most likely be required at the same spot; but for an easy bend, each successive heat should be made slightly further along the tube until the entire length has been shaped to the desired curvature. Chalk marks, which will be perceptible when the tube is red, may be used as a guide when bending at the vice.

WHEELS.

In Figs. 68, 69, 70, 71, and 72 have been illustrated various patterns of cycle wheel spokes. The most troublesome class of wheels to deal with are those having direct spokes, as a spoke broken off short in the hub leaving no projecting portion by means of which it can be removed, must be drilled out. The weakest part of a direct spoke is at or near the point where the screw thread terminates, and it is consequently about that place, which is flush with or below the surface of the hub flange, that fracture usually takes place. Badly made wheels with direct spokes, owing to the threads not being properly fitted, or being of incorrect pitches, from the spoke holes in the hub being drilled and tapped at an angle unsuitable to the diameter of the wheel, or from other faults of construction, will be found to be constantly shedding their spokes. The proper remedy for these defects lies in the substitution of a new hub, although the

first mentioned may be remedied to a certain extent by tapping out the spoke holes in the hub to a larger size, and respoking the wheel.

When a direct spoke breaks off, which, as above mentioned, it usually does just flush or slightly inside the hub flange, the extraction of the stump is a matter of very great difficulty. The first thing to do is to flatten the top of the broken spoke by means of a small punch, the end of which is of such dimensions as to fit the spoke-hole. As soon as the rough top of the stump has been thus rendered level, the punch being applied and the hammer used lightly, a centre punch, also fitting the bore of the spoke hole, is applied, and the stump carefully centred. To drill out the fragment a left hand drill should be employed, and if the spoke be anything of a slack fit, it will most probably after a time unscrew, in which case it can be removed without in any way damaging the hub. In any case the drilling of the hole should be commenced with great caution, and it is well before going far to remove the drill, and minutely examine the hole, when, if the drill is found to be going to one side, the error should be corrected by means of a small centre punch. This operation is, it will be seen, precisely the same as that employed for removing broken studs, &c., by mechanics when executing repairs to heavy machinery. In this case, however, the hub being usually made of gun-metal, whilst the broken spoke end is of steel, the drill will develop a strong tendency to run off into the gun-metal, owing to its being less hard. The work is besides so extremely fine that it is a very critical operation, and great care has to be exercised to avoid damage to the spoke hole. For drilling out the fragments of spokes an ordinary breast drill of any efficient type may be employed by a skilled operator, but it will generally be advisable to use a drilling machine, which admits of the drill being set to any desired angle, and preferably self-feeding. An efficient form of spoke drill will allow with care, when handled by a skilled operator, of a hole being drilled down the centre of a 16-gauge spoke.

A very simple and uncostly type of drill, which can be used either as a spoke drill for lugs, lapped joints, &c., or with the clamp removed as a breast drill, is illustrated in Fig. 294.

For guiding the drill when only one particular size of wheel, form of hub, and gauge of spoke have to be dealt with, a simple device, which consists merely of a jig or guide, not adjustable to all angles, can be employed. This attachment comprises a casting capable of spanning the flanges of the hubs, and grooved at its base to fit to the latter. Through the head of this casting is drilled a hole at an angle suitable for the wheels to be operated upon, and into this hole is fitted a hardened steel plug, drilled out to serve as a guide for the drill that it is intended to use. The device may be secured to the hub by clips, or in any convenient way.

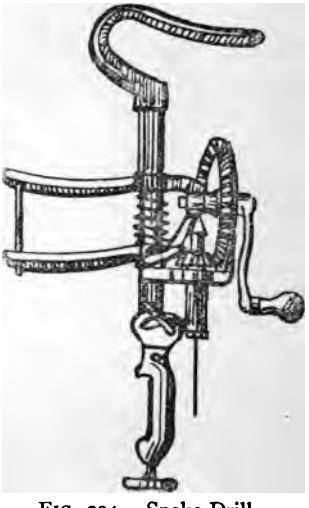

FIG. 294.—Spoke Drill.

The replacing of a direct spoke, which has a stripped screw-thread, is of course a very simple matter, provided the requisite screwing tackle be at hand to screw the new spoke to the correct gauge and pitch. A not uncommon practice with many cycle repairers is to screw the spoke to the nearest pitch on their screw-plate, and then to pass their tap into the hole in the hub. Even when the difference between the pitches of the threads is very slight indeed, this is obviously a most objectionable and unmechanical expedient; but when the said difference in pitch amounts to anything considerable its practice is totally inadmissible. A party undertaking to do repairs of this description should be provided with the necessary tools to carry out the work properly, but in the event of the thread in the hub being perfect and the operator not being possessed of a screw-plate having a thread of the desired pitch on it to cut the screw-thread upon the new spoke, and its being impossible from any reason to procure one, it would be better for him to proceed as he would have to do in a case where both the

male thread upon the spoke end, and the female thread in the hole in the hub were stripped, than to make a botched piece of work by using a screw plate with a wrong thread. This may be effected in two ways, the hole in the hub may be drilled out to suit a larger spoke, and tapped, the spoke end being correspondingly screw-threaded; or else a spoke with an enlarged butt or end, but otherwise of the same gauge as the others, may be employed. The first method is objectionable, inasmuch as not only does a wheel with spokes of different sizes present a most unsightly appearance, but the efficiency of the wheel itself is greatly reduced.

It may happen that the spoke to be dealt with is one which has already been put in to replace one before removed, or even it may be the second spoke so inserted, and the thickness of the hub flange may not admit of the hole being drilled out any larger, and tapped so as to securely hold the spoke end. When this is found to be the case, after drilling out the largest hole the hub is capable of standing, a plug of gun-metal or brass must be inserted and firmly secured in position by soldering, when, after carefully filing up the projecting portion to the outline of the flange, a new spoke hole can be drilled down its centre and tapped to take a new spoke of corresponding gauge to the others in the wheel.

Next take a butt-ended spoke about an inch longer than required, and screw it down into its place, marking it off with a half-round file at the bottom of the countersunk hole in the rim. The spoke should be then withdrawn and accurately cut off to the required length, a handy little tool for which latter operation, fitted with an adjustable gauge, is shown in Fig. 295.

To form or knock up the head, after passing the end of the spoke through the rim, which must be done when spokes with enlarged ends or butts are used, a vice with a spoke clamp having a good grip will be required to admit of this being effected, unless special tools are at hand, by means of which of course the job can be far more easily and satisfactorily performed.

A simple tool for heading butted spokes can be made by taking two pieces of steel, each about 3 in. by 1 in. by $\frac{3}{4}$ in., and filing a V-groove centrally lengthways of each piece.

These grooves must be of such dimensions that, when brought together with the spoke between them, and the blocks or pieces screwed tightly together in the vice, the said spoke will be held firmly in position and endwise movement therein rendered impossible. A suitable countersink must be formed at the top of these V-grooves for the head of the spoke.

An accident which may sometimes happen when carrying out the above repairs, and one undoubtedly the most troublesome that could occur is the breaking of the tap in the spoke hole. The same accident may of course take

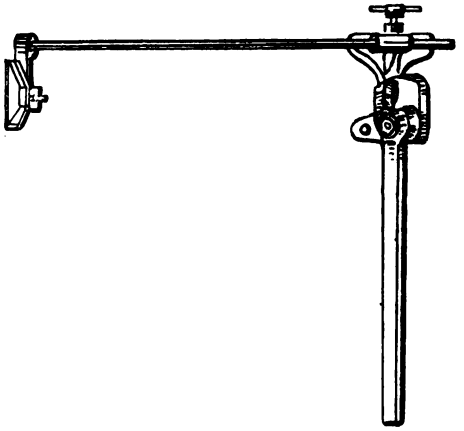

FIG. 295.—Spoke Cutter.

place in connection with a drill when drilling out the said hole; but, compared with the former, this is only a trifling mishap, as unless in the rare event of the shank of the drill having become firmly wedged in the hole through want of clearance, it can be comparatively easily removed by tapping and subjecting it to a vigorous shaking. Not so, however, with the broken tap, here the stump is firmly wedged in position, and the only obvious means of removing it without damage to the hole is by either unscrewing it, or by drilling it out. The first of these plans, when the stump is broken off either flush with or below the surface of the

flange, owing to the small size of the tap, is both extremely difficult and very unlikely to be successful, although a comparatively easy operation when a fragment of a large tap in general engineering work is in question. In the present instance a small chisel that will enter the spoke hole must be made and hardened. Before attempting to unscrew the fragment of tap by chipping, the hub should be warmed over a gas jet, but not sufficiently so to burn off the plating or to melt off the flanges, which are frequently sweated on to the hub. In a few cases the piece of tap will be thus started, and then it can generally be removed without damage to the hub; but, as a general rule, it will be found to be immovable, and the second method will have to be resorted to. This is no easy matter, as the piece of metal to be drilled through is harder than any drill the repairer is likely to have, and the material and construction of the hub will not admit of its being softened by heating. As a general rule, in the event of an accident of this kind occurring, both the above methods will be found a failure, and when the fragment has once been ascertained to be firmly wedged in position, the best plan is to waste no more time on endeavouring to extract it, but to remove by means of a metal saw a wedge-shaped piece containing the spoke hole and the fragment of broken tap. This gap should then be filed out and a correspondingly shaped piece of gun metal or brass fitted neatly into it and firmly soldered in place. A new spoke hole can then be drilled, and the spoke fitted in place. An objection to this repair is that the appearance of the hub is of course spoiled, and can be only restored by replating.

When the cups of the hub ball-race are sweated into their places, and it becomes necessary to remove them, the blowpipe must be used. This should be done with great caution, and the heat applied only until the bright parts commence to change colour, when the cup should be immediately removed and cooled down in water.

In some few instances the hub may be of such a construction as to admit of the application of heat without causing any damage to it. In such a case, a broken tap may be softened by heating, and can then be usually drilled out without much difficulty.

Tangent-spoked wheels are much easier in every way to repair, and unless the broken spoke which it is required to replace be on the gear wheel side, the wheel need not even be removed from the frame to effect the substitution of the new for the broken spoke. When it becomes necessary to remove the wheel in order to effect the repair, the crank upon that side must be first removed, for which operation Brown's patent crank drawer, shown in Fig. 296, would be found convenient. The left-hand threaded screw-washer or nut which usually locks the gear wheel upon the hub must next be unscrewed by means of a proper key, which can be procured from the hub manufacturers. The gear wheel itself, which is screwed on the hub with a right-handed thread, can then be unscrewed and removed. As the position of the gear wheel on the right hand side of the wheel is such that it becomes screwed up or home, under the action of driving, it will usually be found to be very firmly fixed in position upon the screw-threads, and will require a considerable effort in most cases to start it. It is not advisable, as a rule, to resort to gripping the gear-wheel in a vice and unscrewing the wheel, as more or less damage to the parts not infrequently results therefrom. The gear wheel can be generally easily unscrewed by means of a hardwood lever and a piece of stout cord; or, better still, by means of a special wrench adapted to engage without damage with the teeth of the said gear wheel.

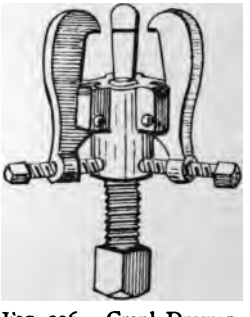

FIG. 296.—Crank Drawer.

The operation of inserting a new tangent spoke is simplicity itself, all that is requisite being to remove the soldered wire wrapping from the meeting point with the other spoke by an application of heat, when the damaged spoke can be immediately pulled out, a new one of a like gauge inserted in its place, and screwed up. Where the thread is good, the old nipple may be used, but in cases where this is damaged, the nipple should be replaced by another one of a similar pattern. The wire used for binding together the

spokes at the points where they overlap is usually tinned copper wire of about 24 gauge.

After the damaged spokes of whatever type have been removed and replaced by new ones, their tension must be carefully adjusted. It is obvious indeed that should any spoke or set of spokes be screwed up too taut with reference to the adjacent ones, not only would the rim be thrown out of truth, but these particular spokes would be caused to bear a far greater proportion of the load, and the threads would strip or the wire break in consequence. In cases where any considerable number of spokes, situated close together, have been replaced, all the spokes must be as carefully adjusted as in the case of a new wheel. In effecting this it is necessary to proceed with great caution in order

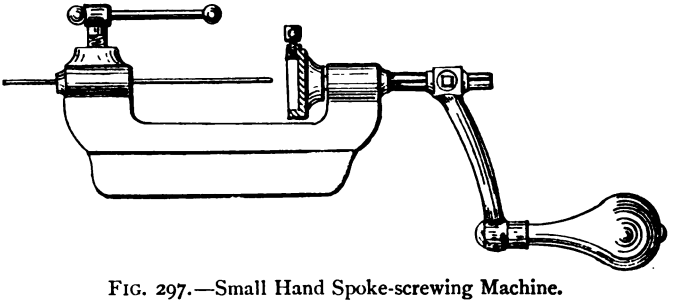

FIG. 297.—Small Hand Spoke-screwing Machine.

to avoid the formation of flat or hollow surfaces upon the rim, and to maintain the latter in a state approaching as nearly to a perfect circle as practicable. For this reason the newly inserted spokes should be tightened up by slow degrees. Finally, such slight adjustments as may be necessary to remedy any small lateral untruths should be made by unscrewing and screwing up adjacent spokes, care being taken that the nipples are only turned through a very small angle at each adjustment; and, moreover, that the nipple on each adjacent spoke be moved to a like extent in obverse directions. The nipples should never on any account be turned through more than half a revolution. Whilst trueing up or adjusting the wheel, it should be frequently spun, so as to detect the formation of any irregularities in the rim.

For this purpose a machine such as that which has been shown in Fig. 273 will be required.

For screwing the end of the spokes the repairer, if not possessed of a regular spoke-screwing machine, may employ a spoke-plate and jig. Several very handy forms of little machines, suitable for screwing the spokes by hand, may also be procured. These hand screwing machines would be found far more efficient than the ordinary screw plate and die-stock, but they are not capable of doing the work much faster, as they are not fitted with any arrangement for automatically opening the die when the desired length of thread has been cut, and for returning same to its starting point, or for unscrewing the die after it has cut its thread at an accelerated speed. A machine of this class is shown in Fig. 297, which possesses all the necessary elements for the performance of accurate work; and a somewhat more complicated machine, which will be found more serviceable when a larger quantity of work of this description has to be done, can also be procured.

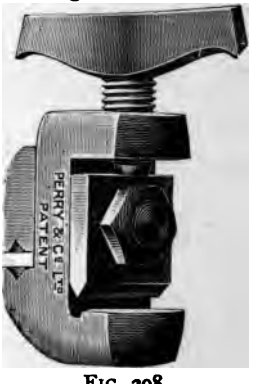

FIG. 298.
Combined Spoke Grip and Nipple Key.

Fig. 298 illustrates a combined spoke grip and nipple key of a patented form made by Perry & Co. Limited.

MACHINED WORK.

It will never pay in a repair shop to make specially parts which can be procured ready turned from the maker of the cycles, or from manufacturers of the component parts. But machines of obsolete patterns will of course be frequently brought into all shops for repairs, and in some indeed this class of repair will most probably be found to constitute the bulk of the work, and it is absolutely necessary, therefore, that the cycle repairer be able, when required, to tackle such jobs as the turning up of special crank axles, pedal pins, spindles, discs, cups, cones, &c. &c.

To effect this the tools at command must comprise a good screw-cutting lathe. The most useful lathe for this class of work is one of the pattern shown in Fig. 299, which is a hollow spindle capstan lathe. It has single geared fast and loose headstock with steel spindle running in conical gun-metal bearings, with a 2-inch hole through its entire length. The end of the spindle is fitted with Brown's patent ball bearing thrust motion, which takes all the end thrust of the spindle, and greatly reduces the friction of large hollow

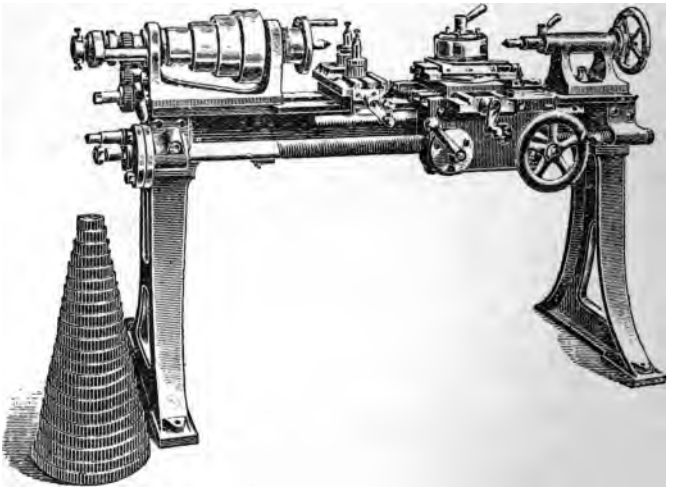

FIG. 299.—Hollow Spindle Capstan Lathe.

spindles. It also carries a centring chuck with four set screws, at the end of the spindle, for helping to hold large bars. The cone is of large diameter, for the use of an exceptionably wide driving-belt. The bed is accurately planed and scraped true to a surface plate, and carries a saddle fitted with a compound slide-rest and turret head for four or six tools, with either round or square holes. The leading screw, which is of steel, is fitted with a gun-metal double disengaging nut worked by a hardened steel cam and lever. The lathe is supplied with two steel centres, a catch-plate, a

face-plate, a set of change wheels, complete overhead motion, and all the necessary handles and spanners. A reversing overhead motion is also supplied, and all the reverse wheels on the lathe are of forged steel, and the gearing machine cut. It has 6 in. centre by 5 ft. bed.

This lathe, in addition to being a most useful tool for screw cutting and any ordinary lathe work, is especially adapted for the requirements of cycle makers or repairers. It can be used for turning the cups and cones direct from the solid bar instead of using stampings.

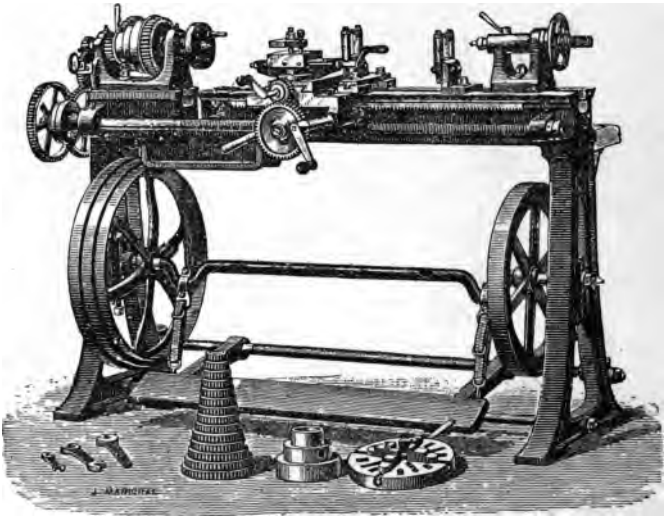

FIG. 300.—Self-acting Screw-cutting and Surfacing Treadle Lathe.

In shops, however, where no power is available a treadle lathe will have to be employed. For this purpose a 5-in. self-acting screw-cutting and surfacing lathe, with 5 ft. bed, adapted to admit between the centres work up to 2 ft. 6 in., of the type shown in Fig. 300, would be found especially suitable. The saddle of this lathe has T-slots for allowing of bolting down the articles to be bored. It is fitted with a compound slide-rest of an improved

pattern, and has quick hand-traversing motion. The headstock is double-geared, the gear being cut out of the solid, or it is provided with single speed, with an antifriction conical neck and a steel spindle. The loose headstock or back centre is bored and ground out perfectly true, and is also fitted with a steel spindle. A driver-plate, face-plate, turning rest, 22 change wheels, and necessary spanners are provided

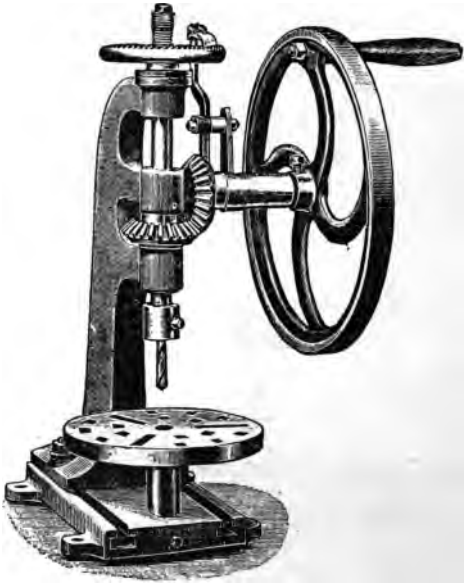

FIG. 301.—Bench Drilling Machine.

with the lathe. As will be seen from the illustration, the lathe is fitted with a treadle and fly-wheel for foot-power, the fly-wheel shaft being carried on antifriction bearings, and so greatly reducing the power required to drive. A hand wheel is also provided for very slow work.

A drilling machine is another tool which will also be required. A handy form of hand bench drilling machine is shown in Fig. 301, and an upright drilling machine for power in Fig. 302. This latter machine (Barnes' patent) has a

20-inch swing, combines lever and screw feed and quick return. It is capable of drilling to the centre of a 20-inch circle. Height, 67 inches; diameter of spindle, $1\frac{3}{8}$ inch; vertical travel, $9\frac{1}{2}$ inches; distance from spindle to floor, 36 inches. The weight of the tool is 500 lbs.

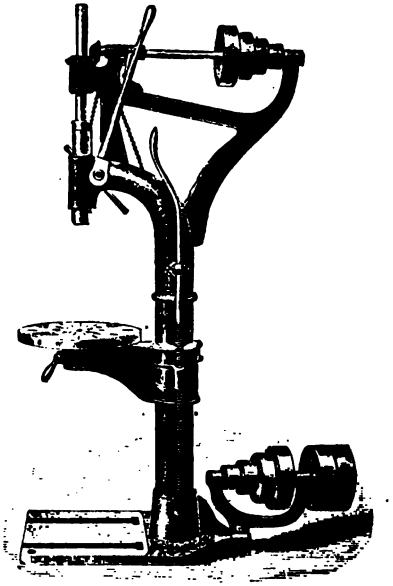

FIG. 302.—Patent Upright Drilling Machine.

CHAIN OR SPROCKET WHEELS.

The diameters of blanks for gear or chain wheels are found, and the cutting of the latter is performed, as follows:—To find the diameter of a gear, chain, or sprocket wheel the pitch circle is used. The pitch of the teeth is the distance from one tooth to another, and is measured either round the pitch circle, or straight across from centre to centre. The first is called the arc or circular pitch, and the second the chord pitch. When toothed wheels are of considerable

diameters and of fine pitch, the difference between the two measurements is infinitesimal; but when of small diameters and of coarse pitch, it is naturally considerable, and consequently, in the case of chain or sprocket wheels for cycles which belong to the latter class, the arc or circular pitch should always be used. Chain wheels for cycles are now almost universally made of 1-inch pitch. To find the diameter of the pitch circle it is only necessary, when the number of teeth required is known, to multiply the arc or circular pitch by the number of teeth required in the wheel, which gives the circumference of the pitch circle, which latter, divided by 3.1416, will give the diameter. For prac-

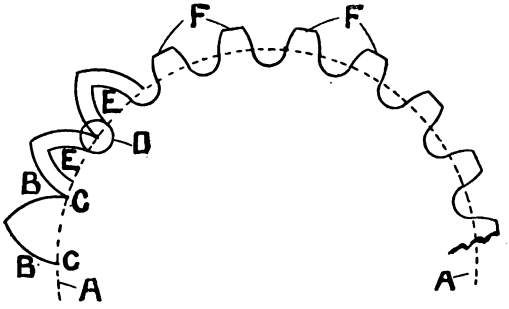

FIG. 303.—Diagram showing Method of Laying out Epicycloidal Teeth.

tical purposes it will usually be sufficient to use 3.14 or $\frac{314}{100}$ or even $3\frac{1}{7}$.

The teeth of cycle chain or sprocket wheels should be of epicycloidal form, which is the only true one for gear wheels. The full explanation of the principle of the designing of this form of teeth is one that would occupy a very considerable space, but a ready method of laying out such teeth for a chain or sprocket wheel has been admirably given in a simple and condensed form by a well-known authority upon matters connected with cycles, and we cannot do better than reproduce his remarks upon the subject:*—"Draw the pitch circle, A, Fig. 303 (wheel for open link or roller

* "Derwent," *English Mechanic and World of Science*, 1894, pages 70, 71.

chain 1-inch pitch, rollers $\frac{3}{8}$-inch diameter), and divide into the requisite number of teeth, as at C, C, with the distance between each as radius. Describe the curves B, B, from the points C. These curves form the teeth, but we require to reduce the size without altering the nature of the curve. This we do by setting a pair of compasses to the radius of the roller on chain, describe the circle D, and with the compasses set to the curve of B from each side of circle D, describe the curves E, which form the sides of the teeth. The top is then reduced or flattened, as shown in the resulting teeth F. The Humber or block chain wheels are laid out in the same manner, but the spaces are wider to take the block—usually $\frac{3}{4}$ inch—and the teeth narrower. The depression, or seating, below the pitch line is not so deep, the radius of the circle D being in this case the distance from the centre of the chain rivet to the outside of the block."

As regards the best cutters to employ for cutting such a wheel, it is, he remarks, a difficult matter to offer advice, without knowing the resources available in the way of tools, but in a general way he suggests that for such a piece of work a fly-cutter, ground to the radius of D, and a second cutter for clearing the sides of the teeth, would be the most suitable, unless sufficient power be available for driving a circular cutter, which will form the whole of one space at one cut. The fly-cutters should be carefully and accurately made to an exact template of the tooth side, and in such a manner that they can be sharpened by grinding the face, and without altering the form of the cutter. In actually machining the blanks, no setting out will be required, if the lathe is supplied with a division plate. The blank is held in position on a mandrel between the centres, and some sort of stop fitted to the slide which advances the gear-cutter, so that it can only cut so far, which is the bottom of the space between the teeth, which has been already found, as above described, on paper. If this adjustment be correct, then the resulting teeth and spaces will also be correct.

TYRES.

The repair of tyres now forms an important, if not the chief, item in cycle repairs, as since the use of pneumatic-

tyred machines has become all but universal, the tyres are the weakest and most vulnerable parts.

The repair of a solid indiarubber or of a cushion tyre, indeed, is a simple and infrequent operation, and can be very expeditiously performed.

Repairs to solid tyres consist in re-cementing in place upon the steel rim or felloe, the jointing together of the extremities of a cut tyre, and the jointing in of a new piece to replace a defective piece that it had become necessary to have cut out.

To effect the first of these operations, the tyre should be completely removed from the rim by warming the latter, by means either of a portable spirit tyre heater, or a gas tyre heater. Thoroughly clean off all the old cement from both the tyre and rim, and wash over with naphtha, or naphtha and spirits of wine mixed, to clean off any grease from the surfaces. Carefully heat the rim or felloe all over to prevent twisting, and then heat it sufficiently piece by piece to allow the cement being rubbed on from the stick. The cement may be made by dissolving shellac in turpentine, or guttapercha in chloroform.

FIG. 304.
Gas Cement Heater.

Fig. 304 illustrates a gas cement-heater made by Fletcher, Russell, & Co. Ltd. When the entire rim or felloe has been thus evenly covered or coated with cement, the tyre should be placed in position and heat applied to the inside of the rim until the cement begins to boil out round the tyre, when the application of heat should be stopped and the tyre carefully adjusted in position and allowed to cool for a few hours, after which the surplus cement may be cleaned off the rim with naphtha. If the tyre be at all slack upon the rim it will be found desirable to bind it completely round with tape or twine, so as to maintain it firmly in position until cool, when the wrapping can be removed.

The jointing of a cut solid tyre, either to reunite the ends or to insert a new piece to replace a damaged part, is best

effected by means of vulcanisation. A more ready method, however, is to unite the parts by means of indiarubber solution. The tyre should be cut with a wet knife, the cut or cuts being made so as to leave the ends taper or wedge-shaped, and the surfaces having been first well cleaned with mineral naphtha, the parts should be plentifully smeared with indiarubber solution, joined, and bound with broad tape, which should not be removed until the joint is dry. For additional security, the adjacent ends may be stitched with copper wire slightly below the line of the felloe or rim edge.

Another method of joining consists in bevelling the ends from an inch to an inch and a half in length, using a long-bladed knife dipped in water, and taking especial care to make clean cuts. The ends should then be coated with the indiarubber solution and allowed to about half dry, which will be in say fifteen or twenty minutes, after which they may be pressed together and will then adhere firmly.

Indiarubber solution is made by dissolving pure indiarubber in some solvent which has also drying qualities, about the most suitable for the purpose being mineral naphtha.

The repairs required by cushion tyres are much the same as those usually called for in the case of solids, and the mode of effecting the said repairs does not differ to any material extent. The use of both these classes of tyres is becoming very rare, however, except upon goods carriers, and doubtless in the course of a few years they will have entirely disappeared, so far at least as other types of cycles are concerned.

The repairs required by single tube or hose-pipe pneumatic or air tyres consist in re-cementing in place upon the rims or felloes when become loose, and in plugging any holes or perforations therein.

The re-cementing of a single-tube pneumatic upon its rim is performed in practically the same manner as that adopted for a solid or for a cushion tyre, the only difference in the method of manipulation being that, when placed in position upon the rim, it should not be quite fully inflated, and after binding, which should not be done too tightly, it should be blown up to its full extent.

To attach the tyre to a wood rim a liquid cement must be

used, as heat is not available in this case. The best liquid cement for the purpose is that chiefly employed in the United States, where wooden rims are in the majority, which consists of shellac dissolved in methylated spirits (90 parts of strong alcohol to 10 parts of wood spirit or methyl alcohol, $\left.\begin{matrix}CH_3\\H\end{matrix}\right\}O$).

The repair of punctures in single-tube pneumatic tyres, or the tearing-off of the valve-nozzle, which latter is a not uncommon accompaniment of the tyre coming loose upon the rim, are usually repairs of a most unsatisfactory description. To effect the first, the hole should be trimmed at the edges and the threads burned away by means of a red-hot wire, and a plug inserted. A good form of plug is that known as Bates', which consists of a stem and an enlarged head, being somewhat in the form of a conical-headed bolt. To use this plug, it is plentifully coated with indiarubber solution and the head inserted through the perforation in the tube. Indiarubber solution should also be freely injected into the interior of the tyre, and distributed on the inner surface as well as possible by external manipulations of the tube. As soon as the plug is in position the tyre must be partially inflated, and when the indiarubber solution has dried, the projecting portion of the stem of the plug should be cut off. These repairs are only effective for small holes; repairs to large ones do not last for any length of time, and are incurable.

The only way to repair a torn-off valve-nozzle is by vulcanisation.

With respect to built-up pneumatic or air tyres, more varied if not more difficult problems not infrequently present themselves. Every tyre devised up to the present possesses some objectionable features, a thorough knowledge of which, and of the best manner of overcoming the obstacles attending the satisfactory execution of any repairs thereto, can only be attained by experience. In making these remarks, reference is only made to the more modern forms of easily detachable tyres; such tyres as those made some four years back by the Dunlop Company, which are known as non-detachable Dunlops, are practically non-repairable, and the proper place for such a tyre when it refuses to hold air is

the rubbish heap. A well-advised professional cycle repairer will immediately and decidedly refuse to have anything to do with the repair of one of these non-detachable Dunlops. The amount of time that would almost infallibly be consumed in effecting a tolerably efficient repair would be far more than the tyre is worth; and such a job is therefore only fit to be undertaken, if at all, by some amateur repairer for himself, and then only in the case that he has an almost unlimited amount of spare time on hand which can be occupied in no useful manner, and is gifted, moreover, with an extraordinary amount of patience and perseverance.

Should, however, any such unfortunate individual, or an ill-advised professional, decide to tackle the repair of one of these tyres, he will have to proceed shortly as follows:—The method of securing the tyre upon the rim or felloe of the wheel, which latter consists of a nearly flat strip of steel, is by providing the outer cover, which encloses the air-tube, with a series of flaps upon each of its sides so cut that they will, when in position upon the rim or felloe, overlap each other in the spaces between the spokes. To place the tyre upon the rim or felloe, all the flaps upon one edge of the outer cover are first secured to the former, between the spokes, by means of solution, and when dry the inner inflatable air-tube is placed in position, the outer cover folded over it, and the flaps upon the other edge are in their turn fixed by means of solution over the first ones.

To effect a repair it is of course necessary to get at the inner inflatable air-tube, and to do this it will be necessary to detach from the rim sufficient of these flaps at both sides of the outer cover to form an aperture wide enough for the purpose. The flaps are detached by dissolving the solution with naphtha in the usual manner, and as the aperture must be coincident with the joint of the inner inflatable air-tube which is situated a few inches on either the one or other side of the air inlet valve, the flaps must first be detached in the vicinity of the latter. A suitable opening having been formed, the valve must be unscrewed, the canvas tube, which resists the air pressure and maintains the inner tube in shape, cut open, and the inner tube drawn through to discover the joint, when if the slit be not sufficient it must be extended so as to lay bare this joint and enable the

operator to dissolve it by means of naphtha and separate the two ends of the air-tube. A piece of cord of sufficient length must next be attached to the opposite end of the said air-tube from that at which the valve is connected, by means of which cord it can be drawn back again after being repaired. The air-tube may then be removed by pulling out the end to which the cord is not attached, either to the extent of the entire tube or until the damaged portion is sufficiently exposed to be get-at-able for patching.

The puncture in the inflatable inner air-tube having been made good by the application of a suitable patch, it may then be returned to its original position. This is effected by drawing the inner tube back by means of the cord, the free end of which has been retained without the tyre, cleaning the edges of the joint and remaking the latter, which is effected by turning back the outside end and coating with solution, as likewise the end that is to go on the inside, when about half dry, place the one end inside the other and turn that portion that has been previously turned back over it. Next, the valve tube must be placed in the proper position, and the cut in the canvas retaining tube carefully sewn up with strong flax thread, and strengthened if necessary by bands of tape. And, finally, the outer cover resolutioned in position exactly as before, an operation requiring some skill and care and the partial or sufficient inflation of the inner tube to impart to it its proper shape.

These different operations are in any case sufficiently complicated, but in practice a repair of this description is almost always rendered more so by various unexpected and unlooked-for difficulties which arise in the manipulation of the different parts. For instance, it is seldom possible to withdraw the inner air-tube without a considerable amount of coaxing and trouble, by reason of its sticking or jamming in the outer cover. To prevent the joint which has been dissolved from sticking to the inner surface of the outer cover, a very liberal application of French chalk must be made to it, and the same must be done to the entire tube when replacing it in position. Great care is also required in fastening the cord to the end of the inner tube to prevent the cutting or turning over of the said end whilst being drawn round the rim or felloe; the best way of securing the

cord to the tube end is by means of a sort of bastard timber hitch, or an ordinary knot, and one or more half hitches about an inch from each other. When solutioning the outer cover in position, the flaps on one side should be solutioned on first and allowed to dry before placing the others in position.

It is a fact that speaks volumes for the valuable attributes of the pneumatic tyre that such productions as this did no more than temporarily check its popularity and the spread of its use.

The modern built-up pneumatic tyre, with readily detachable outer cover, is very easily repaired so far as punctures are concerned, the chief difficulty, indeed, usually experienced being in the precise location of the perforation. The facility of repair is of course governed by the ease with which the outer cover can be removed from, and replaced in position upon the rim or felloe of the wheel. The type of detachable tyres with outer covers having some form of wire fastening are, when of proper construction and mounted upon rims or felloes of suitable forms in transverse section, readily enough detachable for all practical purposes, if not quite so much so as those with enlarged edges and depending upon wedging action for maintaining them in place. The most easy to repair, however, and also those capable of having such repairs, when they consist of patches, to close punctures or perforations, placed in the proper position—viz., on the interior surfaces of the air-tubes—are tyres of that class wherein the inner inflatable air-tube is entirely dispensed with, and which are known as "tubeless" tyres. In replacing these latter tyres in position, however, great care must be taken to avoid any grit or dirt finding its way between the parts, which might prevent the formation of tight joints and cause leakage to occur.

The exact location of a puncture in the air or inner tube of a pneumatic tyre is most easily detected by removing it from the wheel, and passing it section by section through a vessel filled with water, having first inflated it to as great an extent as can be done with safety. When the position of the perforation is indicated by the appearance of bubbles of air, it should be accurately marked by means of a pencil, so as to enable the spot to be found upon the drying of the

tube, on removal from the water. In the event of there being no water available, as in the case of puncture of the tyre happening on the road, the best substitute for the water is to pass the tube close to the ear, the perforation being located by the hissing noise made by the escaping air.

The exact point at which the hole is situated being found, the repair is a very easy matter, only necessitating the application of a small patch. For the latter, thin pure sheet indiarubber will be required, which should not exceed .014 inch in thickness. The material used for the patch being supported by the outer cover, does not require to be of any great strength, and if it be unable, owing to its strength, to expand at the same rate as the air-tube, on inflation of the latter, the patch will be torn off. In repair outfits, the patches, which run from $\frac{3}{4}$ inch in diameter downwards, are provided ready cut; for making them in quantities, punches similar to those used for cutting gun wads are the best. The solution used for sticking the patches should be quick drying, and the great secret of success is to thoroughly clean up both the surface of the air-tube and of the patch. To effect the latter they must be rubbed with glass-paper until the pure indiarubber surfaces are exposed, the cleaning operation being completed by wiping them over with naphtha. Both the exposed pure rubber surface of the air-tube and of the patch should be coated with solution, and after this has nearly dried, the latter may be placed in position, well dusted with French chalk, and left with a weight upon it to completely dry. On an emergency, however, the air-tube may be replaced, the outer cover put on, and the tyre used immediately.

Without any visible or ascertainable punctures, an air-tube will sometimes lose its air owing to the material being originally, or having become, porous. The first state is owing to imperfections in the manufacture, or from inferior material; the second by reason of the tube being worn by contact with the edge of the rim or felloe. When a tyre inner or air tube is in this condition, it will frequently hold air perfectly until put into actual use, when it will pass air and run down rapidly. To properly repair a tube of this description is a hard task, owing to the great difficulty generally experienced in locating the faulty parts, and the

only means of effecting the latter is to manipulate the air-tube when inflated, piece by piece under water.

Leaks at the end joints of the air-tubes are faults which are very easily remedied by first washing the interior of the hole with naphtha, then making a liberal application of solution, and pressing until dry.

The joint between the valve and air-tube sometimes leaks. The hole in the air-tube is strengthened, in all properly made tyres, by a piece of canvas solutioned in place, and this latter may give out, and require replacing by a fresh strip of indiarubber backed with canvas.

Another and very frequent source of leakage in pneumatic tyres is from defective valves, and this is more likely to occur with a new valve than with an old one, as it usually arises from some defect in manufacture, and once put right, the valve will remain so for an indefinite period, with an occasional renewal of a washer or packing in some patterns, and of an indiarubber sleeve, &c., in others. The number of different makes and patterns of valves is so large as to render it impossible to go into details respecting the faults to which they are liable, but they are for the most part readily detected and remedied. The Lucas valve will be found to be about the least liable to get out of order.

A.D. 1845 . . . . . No. 10,990.

Carriage Wheels.

THOMSON'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, ROBERT WILLIAM THOMSON, of Adam Street, Adelphi, in the County of Middlesex, Civil Engineer, send greeting.

WHEREAS Her present most Excellent Majesty Queen Victoria, by Her Royal Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Tenth day of December, in the ninth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said Robert William Thomsen,* my exors., admors., and assigns, Her especial licence, full power, sole privilege and authority, that I, the said Robert William Thomsen, my exors., admors., and assigns, or such others as I, the said Robert William Thomsen, my exors., admors., or assigns, should at any time agree with, and no others, from time to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, my Invention of "AN IMPROVEMENT IN CARRIAGE WHEELS, WHICH IS ALSO APPLICABLE TO OTHER ROLLING BODIES;" in which said Letters Patent is contained a proviso that I, the said Robert William Thomsen, shall cause a particular description of the nature of my said Invention, and in what manner the same is to be performed, to be inrolled in Her said Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said in part recited Letters Patent, as in and by the same, reference being thereunto had, will more fully and at large appear.

* *Sic*, as printed.

NOW KNOW YE, that in compliance with the said proviso, I, the said Robert William Thomsen, do hereby declare that the nature of my said Invention, and in what manner the same is to be performed, are fully described in and by the present Specification thereof, reference being had to the Drawings hereunto annexed (that is to say) :—

The nature of my said Invention consists in the application of elastic bearings round the tires of the wheels of carriages, for the purpose of lessening the power required to draw the carriages, rendering their motion easier, and diminishing the noise they make when in motion. I prefer employing for the purpose a hollow belt composed of some air and water tight material, such as caoutchouc or gutta percha, and inflating it with air, whereby the wheels will in every part of their revolution present a cushion of air to the ground or rail or track on which they run.

Figure 1 is a side view of a wheel of this description, shewn partly in section. The tire and felly T, T, are made much broader than usual, and project considerably at both sides beyond the supporting spokes, as shewn at T, T, in the cross section of the wheel given in Figure II. The elastic belt is made as follows :—A number of folds of canvas, saturated and covered on both sides with india rubber or gutta percha in a state of solution, are laid one upon the other, and each fold connected to the one immediately below it by a solution of india rubber or guttapercha, or other suitable cement. The belts thus formed is then sulphurised by immersion in melted sulphur or exposure to the fumes of burning sulphur, which renders it more pliable and prevents it getting stiff on exposure to cold ; or the belt made be made of a single thickness of indiarubber or gutta percha, in a sheet state and sulphurized, as aforesaid, and then enclosed in a canvas cover. A strong outer casing D, D (Figures 1 and II.), in which to hold the elastic belt, is then built up (so to speak) around the tire by rivetting together a series of circular segments of leather and bolting them to the tire, in the manner shewn in Figure 2. The segments at two of their edges *a*, *a*, Figure 2, are made to overlap each other, as shewn, and then secured in their place by passing bolts G, G (Figure II.) through the tire and felly, and making them fast by nuts *g*, *g* (Figure II.). The elastic belt (C), Figure II., is then layed upon the portion of the segments D, D, Figure II., thus made fast to the tire and secured in its place by bringing the two remaining and as yet unjoined edges *b*, *b*, Figure II., of the segments together over the casing, and connecting them together by rivets F, F (Figure II.). A pipe P, Figure 1, through which to inflate the elastic belt with air, is passed at one place through the tire of the wheel, and fitted with an air-tight screw cap. I

prefer distending the elastic belt with air, as being more suitable than anything else for the purpose, but they may be distended with various solid substances of an elastic quality, as for instance, metallic springs, sulphurised pieces of caoutchouc or gutta percha, or horse hair, or sponge. If the elastic belt were first stuffed with horse hair or sponge, or other elastic materials, and then inflated by blowing in air to a high degree of tension, the belt would be less liable to be cut by concussion between the tire of the wheel and the roadway. Instead also of the elastic belt being made in either of the modes aforesaid, it might be formed of a number of separate tubes, of smaller dimensions, clustered together and enclosed within a leather cover (D). A wheel with a belt constructed in this manner is shewn in Figures III. and IV., the former being a side view partly in section, and the latter a cross section. The tubes are nine in number, and each of length sufficient to go round the wheel. They are represented as tied at the ends, but, for greater convenience of inflation, may be closed by screw caps at one end; the whole are enclosed in a leather cover D. If the three tubes which are shewn in the cross section, Figure IV., as coming next the tire, were filled with air more highly compressed than that contained in the tubes which come in contact with the ground, this would serve to graduate the resiliency of the belt, in a manner highly favorable to the efficiency of its action. Any undue displacement of the air at the bearing points of the wheel may be prevented by tying the tubes across at distances of two or three feet apart, so that each tube shall be divided into a number of separate air-tight compartments. Or, instead of any of the preceding modes of construction, the belt may be formed of separate and distinct sections, as shewn in Figures V. and VI., each section having its own air-pipe (P), in which case the range of expansion and contraction being limited by the extent of the compartments, the belt must necessarily offer at each point of contact with the ground a greater degree of resistance to compression; and in some cases where, from the nature of the roadway, frequent concussions are likely to take place, a flat strap or band of sulphurized caoutchouc or gutta percha, or other suitable elastic substance, of the width of the tire, and about half an inch in thickness, might be interposed between the tire of the wheel and the elastic belt, so as to render it less liable to rupture in the event of its being jambed between the roadway and the tire. Where the leather cover of the elastic belt is likely to be exposed to much tear and wear, I propose to use a belt of the description shewn on the cross section, Fig. VI. Here one of the pieces D^1 is secured to the tire of the wheel by bolts or screws, and it is bent round and sewed or rivetted to the other piece D^2. The edges of D^1 overlap the edges of D^2, and the

outer casing E is secured to those edges by strong leather thongs. This arrangement will permit of the ready removal of the outer casing (E) when worn, and the substitution of a new casing, without disturbing the elastic belt or its attachment to the wheel. And in all cases the outer casing (D or E) may be protected from wear by covering the outer surface with flat-headed metal rivets secured on the inside with small washers. For common passenger carriages the elastic belt will require to be about four or five inches in diameter, and to be inflated to such an extent as to keep the tire of the wheel two and a half or three inches from the ground, a distance which, it is presumed, will be found sufficient to admit of the wheel passing over any stones or other matters projecting beyond the general level of any ordinary turnpike road without the solid tire coming in contact with them. In carriages to which these elastic belts are applied the springs now in use may be dispensed with. In waggons for the carriage of goods the belt ought to be made of stronger materials and of larger diameter than in the case of passenger carriages, and the outer leather cover should be protected by flat-headed metal rivets secured by small washers, as aforesaid. Wheels with elastic belts, such as I have described, may be used with great advantage on timber railways, especially if the modification represented in Figures VII. and VIII. are adopted. The wheels in this case might be of the common form, except they should have a greater width of tire given them, and be without flanges. The carriages are proposed to be kept on the rails by guide wheels (K, K,) working on a shaft L, secured by stays to the carriages, and acting on a raised rail (M) laid between the lines of rails on which the bearing wheels run. The rails (R, R,) are to be made of longitudinal beams of timber, say, of twelve inches broad and six inches deep across ; ties of timber (T, T,) are to connect the two longitudinal rails together, and to these cross ties the longitudinal rail on which the guide wheels act is to be fixed. I prefer employing guide wheels to attaching flanges to the bearing wheels, but the latter also may be used. To increase the bite of the driving wheels of the locomotive I insert in the outer cover of the elastic belt a large number of rivets with sharp conical heads.

The Drawing, Figure VIII., shews a side view of a pair of railway wheels on this plan, for running on timber rails, and Figure VII. a cross section and end elevation of the same. The elastic belts are also peculiarly applicable to carriages propelled by steam on common roads. The comparatively small amount of power required to propel carriages, the wheels of which are fitted with these belts, the steadiness of their motion, the absence of all jolting and consequent security of the machinery from injury, the small damage the carriages will do to roads, the

absence of nearly all noise, the high speed that may safely be attained, and the great gentleness of the motion, will, I think, enable steam carriages to be run on common roads with great advantage both for carrying passengers and goods.

Among many minor applications which suggest themselves I may mention the great applicability of these elastic bearings for bath chairs, rocking chairs, and other like articles, used commonly either in pleasure grounds or within doors. In the common rocking chair a rolling motion is obtained by resting the legs of the chair on two circular segments. In applying my elastic bearings to this chair I propose to make the circular segments on which the chair rolls about three inches wide on their bearing surfaces, and to secure to these segments an elastic tube of about two inches diameter, so as to interpose the tube between the segments and the floor, so that the chair would roll on and be supported by the elastic tube. I propose further to apply the elastic bearings to rollers for the removal of heavy bodies. Such rollers would be used in the same way that wood or iron rollers are now commonly used, that is, by being placed below the body which is to be moved. The advantage which rollers with elastic bearings would have over hard and metallic rollers are, that a large number of them may be made to bear equally at the same time, even although the ways on which the body is being moved are not quite even.

And having now described the nature of my said Invention, and in what manner the same is to be performed, I declare that what I claim is,—

First, the application of elastic bearings round the tire of carriage wheels, as before described; and,

Secondly, the application of similar elastic bearings to the surfaces of other rolling bodies, as before exemplified.

In witness whereof, I, the said Robert William Thomson, have hereunto set my hand and seal, this Tenth day of June, in the year of our Lord One thousand eight hundred and forty-six.

R. W. (L.S.) THOMSON.

AND BE IT REMEMBERED, that on the Tenth day of June, in the year of our Lord 1846, the aforesaid Robert William Thomson came before our said Lady the Queen in Her Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

Enrolled the Tenth day of June, in the year of our Lord One thousand eight hundred and forty-six.

INDEX.

ABINGDON single link chain, 162.
brake, 237.
"Acatène Metropole" driving gear, 196, 197.
Accelerator, 3.
Adjustable framed dwarf safety, 70.
swinging seat pillar, 70.
or swinging handle-bar, 156.
wrenches or spanners, 244.
automatic tube clamp, 279.
Adjustment, 69-72.
crank bracket, 166-173.
Advantages derived from use of cycles, 1.
derived from use of ball bearings, 94-98.
of tubeless pneumatic tyres, 137, 138.
possible, of Simpson chain, 181.
Æolus ball bearing, 92, 98, 99.
Air cushioned handle-bar, 156.
pressure in pneumatic tyres, proper, 74, 146.
pumps, 146, 147.
tyres, *see* Pneumatic Tyres.
saddles, *see* Pneumatic Saddles.
tube, loss of air by porosity of, 314, 315.
tube, leakage at joints of, 315.
Alignment of wheels, throwing out of, 282, 283.
Aluminium cycle frames, 246.
American ladies' safety, 25, 26.
tandem, 27.
cycle manufacturers, use of combination cranks by, 217.
automatic brake, 239, 240.
Machinist on nickel-plating of small articles, 274, 275.
Anatomical saddles, 226-229.
Anderson, Dr J. W., on anatomical saddles, 229.
Anderson, J., spring cycle frame, 90-92.
Angular sliding vice, 249, 250.
Anodes, surface of, to greatly exceed articles to be nickeled, 276.
distribution of, relatively to articles to be nickeled, 276, 277.
Anthony, A., *see* Harrington, M.
Anti-friction ball bearings, first, 5.
Appendix, Thomson's Specification, 316-320.
Appleby chains, 163.
Humber "Twin" roller chain, 163.
Osmond "Dwarf" roller chain, 163.

Arc or circular pitch, 305, 306.
Articles, small, to nickel-plate, 274, 275.
Ash rims or felloes, 111.
Attachment for preventing bicycle from falling sideways, 12.
Austen, C. T., method of securing spokes at points of contact, 114, 115.
tool for screwing up nipples, 259, 260.
Automatic adjustment of saddle or seat, 72.
adjustable tube clamp, 279.
cycle saddle, 230.
capstan lathe, 265.
brake, 239, 240.
hub-drilling machine, 255, 256.
Axles, manufacturing of, 263-265.

BACKBONE, telescopic, 71.
Bagot pneumatic valve, 146.
tyre, 124.
Bailey's automatic brake, 239, 240.
Balance gear, *see* Differential Gear.
of bicycle, 2, 3.
driving gear, first, 37.
Ball bearings, first, 5.
bearings, 92-104.
chain gearing, 191, 192.
toothed gearing, 182-192, 197-200.
head socket to repair, 287, 288.
race cups, hub, to remove, 298.
Bamboo cycles, 19, 20, 80, 88, 89.
Band brakes, 235, 240.
brakes, foot, 240, 241.
machine, emery, 249.
Bands, steel driving, 194, 195.
Bantam bicycle, 20, 21.
bicycle, wheel load of, 66, 67.
Barker, T., cycle frames, 86.
Barnes' drilling machine, 304, 305.
Barnes, Edward, and Garrison, Joseph, ball or spherical tooth gearing, 198-200.
Barrel or disc adjusting hub, 99-101.
Barrow, L., *see* Guest, C. H.
Bartlett, W. E., built-up, wedge-action pneumatic tyre, 125.
Bates' gear cases, 243.
Baths, nickel-plating, 271, 275, 276.
Battery, power for plating, 271, 272.
power required for nickel-plating, 272.
Beeston Pneumatic Tyre Company Limited built-up pneumatic tyres, 123, 124.
Bell-mouthed lap joint, 284, 285.
Belted joints, necessity for experience in, 288, 289.
Bench drilling machine, 304.
Bending tubes, 289-293.
Bent fork legs, to straighten, 283, 284.
Bernstein, Louis, *see* Thomas and Büttner.
Bevel or mitre wheel driving gear, 195-197.
Bicycle, balance of, 2, 3.
safety, 12, 13.
safety roadsters, 13-21.
safety racers, 21, 22.
safety, ladies', 22-27.
adapted for two or more riders, 27-34.
tandem, 27-32.
sociable, 32-34.
convertible, 34, 35.
spokes, strain on, 115.
traction, 76, 77.
Biggs, *see* Linley and Biggs.

Birmingham Small Arms Company, 149, 150, 218.
Birmingham Small Arms Factory safety bicyle, 9.
Black ground, enamel for, 268, 269.
Blanchard and Magurier, velocipede of, 3.
Block chain, 182.
Blocks for tube bending, 292.
Blow-pipe, 248.
Bluemel's gear cases, 243.
Bodding, A., hub, 107.
"Bone-shaker," 5.
Boothroyd, single tube pneumatic tyre, 121.
see also Shaw, W. T., Boothroyd, J. W., and Sydenham, J. W.
Boston laminated wood rim, 111.
Bottom brackets, 163-177.
Boudard, M., and Crawley, C. H., speed gear, 215.
Bourdon clutch driving gear, 206.
Bowden, F., cycle framework, 85.
Bowley, J. W., wedge-action pneumatic tyre, 131-133.
Bown, W., and Hughes, J. H., ball bearing, 92.
Boys, Professor C. Vernon, driving gear, 195.
on wheel load in tricycles, 38.
dynamics, 62, 63.
ball bearings, 96, 97.
Brackets, lamp, 241.
Brakes, 233-241.
Brampton cycle saddles, 231.
roller chain, 162.
Bransom's gear cases, 243.
mud-guards, 244.
Brazing, 247.
Brent, *see* Harrington & Brent.
Brent, H., *see* Harrington, J.
Bridge piece, 163.
Brief history of the cycle, 3 10.
Broken tap, to remove, 297, 298.
drill, to remove, 294.
Brooks cycle saddles, 231, 232.
gear cases, 243.
Brown, C. W., self-locking ladies' frame, 24.
Brown, C., cycle forks, 158.
Brown Brothers pneumatic saddle, 226, 227.
brake, 236.
crank drawer, 229.
Brush brake, rubber, 236.
brake, ordinary, 236.
Buckling, liability of single forks to, 159.
Buffing lathe, 270.
Buffs, polishing, 270.
Built-up pneumatic tyres, 121-147.
repairs of, 310-315.
Bull-dog rat-trap pedal, 221.
Bunsen flame, brazing by, 247.
Burgess pneumatic saddle, 227.
Burton, C. E., driving gear, 209, 210.
Bush or liner, repair of tube with, 280, 281.
Butler, *see* Westwood-Butler.
Butted spokes, to head, 296, 297.
Butterfly rubber pedal, 218.
rat-trap pedal, 221.
Büttner, *see* Thomann and Büttner.

CAM driving gear, 195.
Can, oil, 244.
Cap for fork ends, 158.
Capstan lathe, automatic, 265.
lathe, 302, 303.
Cardboard cycle frames, 88.
Care of nickeled surfaces, 227.
Carriers, 47.
Carter's gear case, 243.

Carver quadricycle, 53.
Case hardening axles, 264.
Cast-iron, treatment of, for nickel plating, 273-275.
Castle, W. H., adjustable or swivelling handle-bar, 156.
Cellular pneumatic tyre, 142-144, 316-320.
Celluloid mud-guard, 244.
Cement heater, gas, 308.
Central driving gear, 212-214.
Centre of gravity, 75.
Challenge safety bicycle, 7.
Chain adjustment, swing, 175, 176.
driving gear, 7, 161-192.
driving gear, ball toothed, 182-192.
guards, 243, 244.
wheels, *see* Sprocket Wheels.
Chains, pitch, 161-192.
"Cheeta" bottom bracket, 173.
Chord pitch, 305, 306.
Christy, H. A., saddle or seat, 229.
Circle, pitch, what is, 305, 306.
Circular or arc pitch, 305.
Clamp, tube, 279.
Clark, D. K., formula for locomotive traction, 76.
"Clincher" pneumatic tyre, 125.
Clip pump, 244.
saddle, 231.
Clips. toe, 221-224.
for tyres, 244.
Closed lap joints, 286.
"Club" safety bicycle, wheel load of, 65.
safety bicycle, 7.
safety quadricycle, 53.
sliding seat or saddle, 71.
Coats of varnish for japanning, 269.
Clutch driven machines, 205, 206.
Cold bending of tubes, 289-291.
Coloured grounds for japanning, 268.
Columbia bicycle, 19.
Combination crank axle, 217.
rubber and rat-trap foot-rest, 244.
Combined pedal and toe clip, 221.
Component parts of cycles, 79-245.
Components of driving gear, Perry's, 163.
Compound members, frames with, 84, 85.
tyres, *see* Built-up Pneumatic Tyres.
Compressed paper cycle frames, 87, 88.
Compression of tyres, 74.
Cone bearings for cycles, 95.
nut pedal pin, 216.
Considerations, economic, 78.
Convertible pedal, 224.
Convertibles, 34, 35, 90.
Cooper, *see* Marriott & Cooper.
Corded silk dress guard, 244.
Cork handles or grips, 157, 158.
Corrugated tyre, 124.
Cotter pedal pin, 218.
Coupling rods and cranks, driving by, 195.
Courtney, *see* Ross-Courtney.
Coventry chair, 48, 49.
convertible sociable, 53.
rotary tricycle, 203.
Coventry Machinists' Company Limited quadruplet, 31, 32.
ball steering head and lock, 153.
tandem safety, 45, 46.
duplex head, 153.
Covers, pneumatic saddle, 228.
Cowper, E. A., improved cycle, 5, 6.
ball-bearing, 92.
Cox, John, spring handle-bar, 156.
improved saddle, 225.
Crank driving gear, Perry's, 163.

Crank bracket adjustment, 116-173.
bracket, Rudge-Whitworth, 164, 165.
detachable, 176.
drawer, 299.
rotary, application of power by, 215, 216.
Cranks first fitted to cycle, 4.
and coupling rods, driving by, 195.
securing, in position, 216, 217.
variable throw, 202, 203.
long, advantages of, 216.
Crawley, C. H., *see* Boudard, M.
Crecelius, L. J., *see* Grayson, W.
"Cripper" tricycle, 69.
Crowden, C. T., hydraulic jointing, 85.
see also Pausey, H. J.
"Cruiser" quadricycle, 53.
Crypto Works Company Limited front-driving safety, 20, 21, 66, 67.
epicyclic gear, 201, 210-212.
Cups of hub ball race, to remove, 298.
Current, electric, for plating, 271, 272.
Cushion tyres, 116.
tyres, repairs to, 308.
Cushioning strip for built-up tyre, 125.
Cutters for epicycloidal teeth, 307.
Cutting off, tool for, spokes 296.
sprocket wheels, 260-263.
Cyanide bath, 271.
Cycle, advantages of, 1.
brief history of, 3-10.
spokes, strain on, 115.
definition of, 3.
water, 58-60.
and rider, momentum of, 72, 73.
mechanics, 73-78.
Cycle step, 244.
jig, universal, 250, 251.
frames, members of, 289.
Cycle Components Manufacturing Company Limited factory inflator, 259.
spring chain wheel, 193.
Cycles, component parts of, 79-245.
manufacture of, 246-277.
"Cyclet," 18, 19.
wheel load of, 67.
Cycling, letter in, on Simpson chain, 178-180.
Cyclometer readings, 74.

DALZELL, Gavin, bicycle, 4.
Damaged tube, to remove, 282, 284.
Dandy or hobby-horse, 3.
Davies, Preston, bottom bracket, 177.
ball tooth gearing, 184-186.
pitch chain, 185, 186.
barrel hub, 102, 103.
tubeless pneumatic tyre, 133, 134.
Defective valves, leakage of, 315.
Dented tube, mistake to replace, in frame, 279, 280.
Derwent on epicycloidal teeth, 306, 307.
Detachable handles or grips, 157, 158.
crank bearing, 165, 166.
crank, 176.
Devon tricycle, 70.
Devices for closing fork ends, 158, 159.
Dicycle, *see* Bicycle.
Differential or balanced gear, 204, 205, 207, 208.

Different metals, treatment of, for nickel-plating, 273-275.
Dips, *see* Baths.
Direct spokes, replacing, 293-297.
Disc ad usting or barrel hub, 99-101.
wh·els, 115, 116.
Discs or screwed cups, 265.
Distribution of weight, 73, 74.
of wheel load in cycles, 12, 13, 63-69.
Dollies, finishing, 270.
Double tubes, use of, in frames, 84.
tyred and rimmed wheel, 21.
driving tricycles 204.
Dover Horace Walter, joints for bamboo frames, 88.
gear case 243.
Dowson gas plant 247.
Drais, Baron de, bicycle, 4, 56.
Dress guards, 244.
Drop, semi-, handle-bar, 154, 155.
scorcher, handle-bar, 155.
path racer, handle-bar, 155.
Drilling machine, rim or felloe, 253, 254.
machine, hub, 255, 256.
machines, 304, 305.
jig, 286, 287.
Driving band·, steel, 194, 195.
chains, 161 192.
gear, 161-224, 260-265.
gear, cam, 195.
wheel, sprocket or chain, 163.
wheel, to remove, 299.
Drzewiecki, S., driving gear, 206, 207.
rear-driving safety, 18, 19.
D-shaped tubes, use of, in frames, 84.
Dual sets of chain wheels and chains, employment of, 203.
Dunlop, J. B., pneumatic or air tyre, 119-121.
Dunlop, J.B., pneumatic valve, 146.
non-detachable tyre, to repair, 310-313.
Duplex head, 153.
Dwar bicycle, 8.
Dynamic gear *see* Epicyclic Gear.
Dynamics of cycles, 62, 63, 76, 77.
Dynamo electric machine, for plating, 272.

EADIE chain, 162, 163.
Eccentrics and steel band driving gear, 195.
Economic considerations, 78.
Efficiency of cycles, 12, 13, 61-78.
of cycles, variations in, 11, 12.
of cycles, points of, 12, 13, 61.
Electric cycle lamps, 241, 242.
curren for plating 271, 272.
Electro deposition, 269, 277.
deposition of copper, batteries for, 272.
deposition of nickel and silver, 272.
Elliptical lever action driving gear, 7.
Elm rims or felloes, 111.
Elmore, William, Limited, dynamo electric machine, 272.
Elongated dust-proof hub, 103, 104.
Emery grinding machine, 264.
band machine 249.
Enamelling, 266-269.
stove, 266.
Enamels, recipes for, 268, 269.
Energy of motion, 77, 78.
English Mechanic, or World of Science, on epicycloidal teeth, 306, 307.
Epicyclic gear, 200-216.
Epicycloidal teeth, to lay out, 306, 307.

Erecting stand, 279.
Erector, wheel, 260.
Expanding chain or sprocket wheels, 203.

FACILE safety bicyle, 7.
Factor of safety in cycles, 11.
Factory inflator, 260.
Fairbanks laminated or built-up wood rim, 112.
Felloe, double, wheel, 12.
Felloes, *see* Rims.
Felt handles or grips, 158.
Ferrule or tube strengthener, 248.
Finishing framework, 266-269.
Fire-engine cycle, 47.
Fittings and accessories, 241-245.
Flap for built-up tyre, 125.
Flat roadster handle-bar, 154.
road racer handle-bar, 154.
Fletcher, Russell, & Co. blow-pipe, 247, 248.
cement heater, 308.
Fleuss tubeless pneumatic tyre, 136, 137.
Fleuss, H. A., protected tread tyre, 143, 144.
Fly-cutter for epicycloidal teeth, 307.
Foot motor boat, 58-60.
rests, 244.
brakes, 238, 239, 241.
Fork strengthener, 158, 159.
ends, devices for closing, 158, 159.
legs, rear, out of line, to straighten, 283, 284.
ends and chain adjustment, 163.
Forks, 158-170, 283, 284.
single, liability of, to fracture, 159.
Forward racer handle-bar, 155.
Fowler, John, & Co. balance driving gear, 137.
Fowler Cycle Manufacturing Co. truss frame, 85.
differential or balanced gear, 204.
Fracture, liability of single forks to, 159.
Frames, jointing, by hydraulic pressure, 85, 249.
brazing, 247.
putting together, 248, 249.
repairing, 278-293.
Framework, 80-92, 246-257.
French, J. T., *see* Simonds, J. S.
Friction of ball bearings, results o tests on, 98.
Front-driving cycles, ungeared, 4-7.
driving cycles, geared, 7-10. 20, 21, 50, 51.

GARRISON, Joseph, *see* Barnes Edward.
Gas blow-pipe, 247.
cement heater, 308.
furnace, 248.
heated enamelling stove, 266.
or petroleum forge, 248.
Gear cases, 243, 244.
driving, 161-224, 260-265.
interchangeable, 165.
General observations on nickel-plating, 276, 277.
Gibbons three-track tandem, 53.
Glass cutters' sand for polishing 270.
Gompertz, Louis, bicycle, 4.
Goods carriers, 49-51.
Gormully & Jeffery Manufacturing Company wedge-action pneumatic tyre, 129, 130.
pneumatic valve, 130, 131.

Gouzenes, M., wire-fastened built-up pneumatic tyre, 124.
Granger, W., *see* Singer, G.
Gravity, centre of, 75.
Grayson, W., and Crecelius, L. J., cycle frames, 86.
Green, Henry, spring cycle frame, 91.
Griffiths, Alfred, safety bicycle, 9, 10.
on wheel load in cycles, 13.
classification of tricycles, 36, 37.
adjustable swinging seat pillar, 70.
Grilli sociable bicycle, 34.
Grip pedals, 219, 220.
Grips or handles, 156-158.
Griswold rubber mud-guards, 244.
Grose's gear cases, 243.
Ground, black, for japanning, 268, 269.
white, for japanning, 269.
coloured, for japanning, 268.
Guest, C. H., and Barrow, L., joints of cycle frames, 87.
Guide or jig for drilling wheel hub, 295.
Guthrie & Hall's pneumatic saddle, 228.

HALL, R. F., brake, 236.
Hall, J. W., and Phillip's, H. L., method of mounting wire spokes, 114.
see also Guthrie & Hall.
Handle-bars, 19, 153-156, 287, 288.
reversible, 19, 156.
wood, 153.
to repair, 287.
T-piece, 288.
Handles or grips, 156-158.
detachable, 157, 158.
Harrington, J., and Brent, H., ball bearing, 93.
and Brent's method of mounting wire spokes, 112, 113.
Harrington, M., and Anthony, A., joints for bamboo frames, 89.
Harris, W. S., plating small articles, 274, 275.
Hartford single tube pneumatic tyre, 121.
Hatton's universal cycle jig, 250, 251.
Head, ball socket, to repair, 287, 288.
polishing, 270.
spoke, to form, 296, 297.
steering, 147.
Headlight, electric, 241.
Heating tubes for bending, 293.
Helical or undulating spokes, 113.
tubes, 16, 81-84.
Henson's pneumatic saddle, 226, 227.
Hering, Rudolph, traction on macadam roads, 77.
Hickory spokes, 113.
rims or felloes, 111.
Hide, A. C., joints for cycle frames, 86.
High bicycle or ordinary, 6, 7.
History of the cycle, brief, 3-10.
Hobby-horse, 3.
Hollis brake, 235.
swivelling or adjustable handle-bar, 156.
Hollow metallic rims or felloes, 108-110.
or double rims or felloes, 252.
spindle capstan lathe, 302, 303.
Honrath, Alexander, spring tyres, 118.

Horn grips or handles, 157.
Hose pipe or single tube pneumatic tyre, repairs to, 309, 310.
Hot bending of tubes, 291-293.
Hub drilling machines, 255, 256.
turning lathe, 257-259.
ball race cups, to remove, 298.
Hubs, pneumatic, 91.
ball, 92-107.
driving, 163-177.
Hudson, J. G., brake, 235.
Hughes, J. H., ball bearing, 92.
see also Bown, W.
Hull, J. E., spring cycle frame, 91.
Humber safety bicycle, 9.
roadster safety, 13, 14.
adjustable or swinging handle-bar, 156.
racer, 22.
steering or head lock, 28, 29.
lady's safety, 23, 24.
handle-bars, 154-156.
tandems, 28-31.
crank bracket adjustment, 116-173.
triplet, 31.
rat-trap pedal, 221.
tricycle, 40, 41.
dust-proof oil-retaining hub, 101, 102.
"Cruiser" quadricycle, 53.
spring cycle frame, 90.
pattern chain, 163.
seat lug, 232.
swing chain adjustment, 175, 176.
brake, 234, 235.
detachable crank, 176.
pattern toe-clip, 223.
saddles, 231, 232.
steering or ball head adjustment, 148, 149.
Hurndall laminated wood rim, 111.
Hurrell and Spence adjustable cycle, 71.
Husberg, N. K., ball bearings, 93, 94, 217.
brake, 237.
Hyde Imperial Rubber Company Limited built-up pneumatic tyre, 124.
Hydraulic brakes, 237.
jointing, 85.
pressure, formation of lugs, &c., by, 247.
Hydrochloric or muriatic acid bath, 271.

ICE velocipede, 58.
Imperial Rover bicycle, 19.
Indiarubber brakes, 236, 237.
pedals, 218.
mud-guards, 244.
solution, 309.
Inflation of pneumatic tyres, proper, 74, 146.
Inflator for factory use, 660.
Inflators, 146, 147.
Inner socket tube, repair of, 281.
Insertion of tangent spokes, 299, 300.
Insertion of butt-ended spokes, 296.
Interchangeable gear, 165.
Introduction, 1-10.
Iron, cast, to nickel-plate, 274.
malleable, to nickel-plate, 274.
wrought, to nickel-plate, 274.

JAMES, Harry, adjustable hub, 51, 52.
James, J. T., hollow metallic rim or felloe, 110.
inside bead metallic rim or felloe, 110.
single metallic rim or felloe, 110.

Japan metallic surface, to, 266-269.
Jarvis, E. B., saddle, 229.
Jeffery, *see* Gormully and Jeffery Manufacturing Company.
Jig for drilling wheel hub, 295.
universal cycle, 250-257.
Jiggers or jigs, 248, 249, 250-257.
Jointing cut solid tyre, 308, 309.
tubes by hydraulic pressure, 85.
Joints, 234-288.
between valves and air tubes, leakage of, 315.
of air tubes, leaks at, 315.
of bamboo frames, 80-89.
Jones, F. W., adjustable framed dwarf safety, 70.
Journal de Paris, description of Blanchard and Magurier's velocipedes, 3.
Junction pieces, 247.

KAISER safety bicycle, 9, 10.
adjustable swinging seat pillar, 70.
Kay's brush brake, 236.
Kekewich, Justice, judgment by, 123.
Kick, Professor, law of proportional resistances, 74.
King, *see* Kirch-King.
Kirch-King, A. W., cycle frame joints, 86, 87.
Kirkaldy, David, results of tests by, of helical tubes, 81-84.
Kolb's unicycle or monocycle, 55.
Kotin, Adolph, ball tooth gearing, 186-192.
roller hub, 105, 106.
pitch chains, 187, 188, 191, 192.
chain guard, 188, 189.
ball chain gear, 191, 192.

LACED or tangent spokes, 113-115.
wheel and chain guards, 244.
Ladies, safety bicycles adapted for, 22-26.
Laminated wood rims or felloes, 111, 112.
Lamp brackets, 241.
Lancaster, J., spring clips for tyres, 244.
Landis, H. K., on cycle mechanics, 73-78, 81.
Lap joints, 284-286.
Lapped and belted joints, necessity of experience in, 288, 289.
Large diameter tubes, use of, in frames, 84.
Larne, M., unpuncturable pneumatic tyre, 142.
Lathe attachment for emery grinding, 264.
hollow spindle capstan, 302 303.
polishing and buffing, 270.
self-acting hub turning, 257-259.
treadle, 303, 304.
Lawson, H. J., claim of, to inventorship of safety bicycle, 6.
Lazerges, M., unpuncturable pneumatic tyre, 142.
Leather gear cases, 243.
pneumatic tyres, 145, 146.
Lee's automatic attachment, 139.
Lever chain, 177-180.
Liability of single forks to fracture, 159.
Light combined pedal and toe clip, 221.
Lime, use of, for polishing, 270.
Linley and Biggs spring cycle frame, 91.
Liquid cement, 310.
Loane, E. D., air pump, 147.

Location of puncture in tyres, 313, 314.
Lock, Charles, ball toothed gearing, 182-184, 197, 198.
pitch chain, 184.
Long bearings, use of, in cycles, 94.
cranks, advantages of, 216.
Loop frame, lady's safety, 24, 25.
Lucas anti-vibrating handles or grips, 156, 157.
pneumatic valve, 146, 315.
toe clip, 224.
Lug, seat, 232.
Lungren, C. M., tubeless pneumatic tyres, 134-136.
Lycett's pneumatic saddle, 227, 228.

MACADAM roads, traction on, 77.
Machined work repairs, 301-305.
Machines adapted for ladies' use, 22-26.
Magurier, *see* Blanchard and Magurier.
Malleable iron, to nickel-plate, 274.
Mandrel, flexible steel, 289, 290.
Manufacture of cycles, 246-277.
Manumotive or hand-power velocipedes, 55-58.
Maple rims or felloes, 111.
Marriott & Cooper convertible machine, 35.
tricycles, 42-45.
convertible frame, 90.
Matchless sliding seat or saddle, 71.
M'Anney, Grant, joints for bamboo cycle frames, 88, 89.
M'Kenzie cycle, 4.
M'Millan bicycle, 4.
Mechanics of cycle, 73-78.
Metallic surface, to japan, 266-269.
Metals, different, treatment of, for nickel-plating, 273-275.
Method of attaching pedal pin to crank, 218.
mounting ball or spherical teeth, 183-192.
Metropole, *see* Acatène Metropole.
Michelin & Company built-up pneumatic tyres, 127, 128.
Midget oil can, 244.
Milling machine, 261-263.
Miscellaneous machines, 52-60.
Modern built-up tyres, to repair, 313-315.
safety bicycle or dicycle, 11.
tricycles or three wheeled cycles, 36-46.
Momentum of cycle and rider, 72, 73.
Mongiardino, L. E., and Davies, Preston, tubeless pneumatic tyre, 133, 134.
Monocycles or unicycles, 53-55.
Morgan and Wright single tube pneumatic tyre, 121.
Morgan chain, 162.
Morris, G. L., Wilson, W. T., and Strickland, N. H., disc wheels, 116.
cycle frames, 87.
Motion, energy of, 77, 78.
Mud-guards, 243, 244.
Multicycles, 53.
brakes for, 240.
Muriatic acid, *see* Hydrochloric Acid.

NARROW tread pedal pin, 218.
National single tube pneumatic tyre, 121.
New York Electrical World on electric cycle lamps, 241, 242.

Nickel plating, 269-277.
plating cast iron, 273, 274.
plating steel, 274.
plating small articles, 274, 275.
plating tank or vat, 271-276.
plating malleable iron, 274.
plating, battery power required for, 272.
plating wrought iron, 274.
plating, dynamo electric machine for, 272.
Nickeled surfaces, care of, 227.
Nipples, tool for screwing up, 259.
key, 301.
Nitrate of potash, *see* Solution Stripping.
Nitric acid, *see* Solution Stripping.
Non-detachable Dunlop tyre, to repair, 310-313.

OARSMAN tricycle, 56, 57.
Oat tyre, 124.
Objections to self-healing pneumatic tyres, 139, 140, 143, 144.
O'Brien's patent bent-wood handle-bar, 153.
Oil-can, 244.
Open lap joints, 284, 285.
Ordinary block chain, 179-182.
or high bicycle, 6, 7.
or high bicycle, wheel load of, 64.
pedal pin, 218.
Osmond, F. J., on long cranks, 216.
"Osoezi" anatomical saddle, 226, 228.
Otto, E. C. F., undulating or helical spokes, 113.
and Wallis, J., sheet metal wheels, 116.
two-track bicycle, 36, 52, 70, 71, 194.
Oval tubing, use of, in frames, 84.
Oven, japanners', 266, 268.
Ozanam, Jacques, on passenger carriers, 48.

PACKING tubes for hot bending, 292, 293
Palmer, J. F., built-up wedge-action pneumatic tyre, 126-128, 129.
collapsible handle-bar, 156.
puncture-proof pneumatic tyre, 140.
puncture-proof air tube, 140, 141.
improved fabric for tyres, 141.
Papier-mâché cycle frames, 87, 88.
Paraffin oil, use of, to protect nickeled surfaces, 277.
Paragon mud-guards, 243, 244.
Paris, use of cycle fire engines in, 47.
Parson, H., central driving gear, 212-214.
Parts, strength of, 75, 76.
Passenger carriers, 47-49.
Patch, to apply, on air tube, 312-314.
Patent adjustable or swinging handle-bar, 156.
Thomson's, for first pneumatic tyre, 316-320.
Path racer drop handle-bar, 155.
Pattern handle-bar, raised, 155, 156.
Pattison, Sydney, cycle saddle, 230, 231.
Pausey, H. J., and Crowder, C. T., bevel driving gear, 196.
Pavement, traction on, 77.
Peakless saddles, 226, 227.
Pedal, pressure on, 77.
pins, 217, 218.
Pedals, 217-224.

Perforated steel driving bands, 194.
Perry brake, 236.
cycle step, 244.
foot rest, 244.
saddle pin or pillar, 232.
frame for safety, 80.
method of attaching pedal pin to crank, 218.
pedals, 218-223.
elongated dust-proof hub, 103, 104.
steering head, 152, 153.
Humber pattern chain, 163.
components of driving gear, 163.
tricycle axle, 210.
toe-clips, 223.
Phillips, R. E., remarks on passenger carriers, 48.
on variable throw cranks, 202, 203.
grip pedal, 220.
Phillips, H. L., *see* Hall, J. W.
Pichard, C. F., joints for cycle frames, 85, 86.
Pickering bicyle, 4.
Pins, pedal, 217, 218.
Pitch circle, what is, 305, 306.
chains, 161-163, 177-192.
Pivoting teeth, 192.
Plated wire dress guards, 244.
Plating, nickel, 269-277.
tank or vat, 271.
solution, 271.
Plain steel driving bands, 194, 195.
Plugs or stoppers for fork ends, 158, 159.
Pneumatic brakes, 237.
cycle saddles, 225-228.
cycle frames, 91, 92.
saddle covers, 228.
or air tyres, 119-146.
tyres, repairs to, 308-315.
Polishing plated work, 269, 270.
and buffing lathe, 270.
Pope Manufacturing Company safety bicyle, 33, 34.
Porosity of air tube, loss of air by, 314, 315.
Potash bath, 271.
nitrate of, *see* Solution Stripping.
Power consumed in driving, 72, 73.
Practical hints on japanning, 267-269.
Preliminary preparation for nickel-plating, 272, 273.
Premier Cycle Company Limited roadster safety, 16.
helical tubes, 16, 81-84.
racer, 22.
lady's safety, 25.
hub, 99.
rim or felloe drilling machine, 253, 254.
automatic hub drilling machine, 255, 256.
self-acting hub turning lathe, 257-259.
milling machine, 261-263.
Prentice, J. S., Renison, W., and Renison, J., arrangement for facilitating propulsion, 106, 107.
Preparation, preliminary, for nickel-plating, 272, 273.
Pressure, hydraulic, jointing tubes by, 85.
on pedal, 77.
Presto gear case, 243.
Prestwich pneumatic saddle, 225, 226.
Price's cam driving gear, 195.
Priming varnish, 268.
Prussiate of potash process, hardening axle by, 264.
Pulling toe-clip, 222.

Pumps, air, 146, 147.
Puncture, to locate, in tyre, 313, 314.
Puncture Proof Company's speedifier band, 139.
Punctures in single tube tyres, repairs of, 310.
in built-up tyres repairs of, 310-315.
in tubeless tyres, 313.
Punnett Cycle Manufacturing Company sociable bicycle, 33, 34.

QUADRANT quadricycle, 53.
tricycle, 69.
Quadricycles or tetracycles, 52, 53.
Quadruplets, 31, 32.
Quevedo, W. T., hand-power cycle, 57.
Quintets, *see* Quintuplets.
Quintuplets, 32.

RACER, path, drop handle-bar, 155.
forward, handle-bar, 155.
Racers, 21, 22.
Racing men, use of long cranks by, 216.
Raised pattern handle-bar, 155, 156.
Rat-trap pedals, 219-222.
foot-rest, 244.
Raymond, C. M., lamp oil reservoir, 242, 243.
inflator, 147.
Reach, proper length of, 232.
Readings, cyclometer, 74.
Rear-driving geared chainless safety, 18.
geared chainless safety, wheel load of, 67.
Rear-driving safety bicycles, 9-35, 65-78.
chain geared safeties, 11-18, 21-35.
chain geared safeties, wheel load of, 67, 68.
Rear chain adjustments. 165-175.
Rear fork legs out of line, to straighten, 283, 284.
"Record" pneumatic tyre, 124.
Reciprocating crank driving gear, 216.
Referee Cycle Company Limited triple head, 153.
"Reform" saddle, 228.
Reilly, M., tests of helical tubes, 82, 83.
Renison, W., *see* Prentice, J. S.
Renison, J., *see* Prentice, J. S.
Renold chain, 162.
Renouf, P. L., and Westwood, F., pneumatic friction wheels, 192, 193.
— tandem, 27.
Repair work, useful sizes of tubes for, 288.
Repairs and renewals, 278-315.
Replating work, 275, 276.
Rests, foot, 244.
Reversible handle-bar, 19.
Reynold chain, 162.
Richardson's saddle, 229.
Rider and cycle, momentum of, 72, 73.
Right and left hand pedal pin, 218.
Rim, wheel with double, 21.
or felloe drilling machines, 253, 254.
Rimmington, R. F. and J. A., ball tooth gear, 191.
Rims or felloes, 16, 17, 107-112, 252-254.
Riviere, L. F. A. P., cycle, 6.

Road racer, flat, handle-bar, 154.
Roads, good, necessity for, 2.
macadam, traction on, 77.
Roadster, flat, handle-bar, 154.
Roadsters, 13-21.
Roller brake, 237.
hub, 105, 106.
toothed wheels, 197-200.
Rolling resistance, 12.
Roper's angular sliding vice, 249, 250.
Ross-Courtney pneumatic valve, 146.
Rosser's patent pneumatic brake, 237.
Rotary crank, application of power by, 215, 216.
"Rover" safety bicycle, 9.
Royal Mail quadricycle, 53.
Rubber pedals, 218.
mud-guards, 244.
tyres, first, 5.
Rucker tandems, 27.
Rudge-Whitworth roadster safety, 15.
racer, 22.
hub, 99.
steering ball head, adjustment, 148.
crank bracket, 164, 165.
Russell, *see* Fletcher, Russell, & Co. Limited.

SADDLES or seats, 224.
Saddle or seat, adjustment of, 71, 72.
or seat, sliding, 57, 71.
or seat clip, 231.
leather tightening arrangement for, 232.
pin or pillar, 232.
Safety bicycles, 6-10.
addition for pneumatic tyres, 142, 143.
Sand for polishing, 270.
Scarf joints, 286.
Scientific American on cycle mechanics, 73-78.
hints on japanning, 267-269.
Scorcher drop handle-bar, 155.
Scott, R., built-up pneumatic tyre, 124.
built-up wedge-action pneumatic tyre, 126.
Screw-cutting capstan lathe, 302, 303.
Screwed cups or discs, 264, 265.
Seat lug, 232.
or saddle, sliding, 57, 71.
Seats, *see* Saddles.
Seddon, E. H., tyre with auxiliary tube, 124.
Self-acting screw-cutting and surfacing treadle lathe, 303, 304.
hub-turning lathe, 257.
Self-adjusting automatic saddle, 230.
Self-sealing pneumatic tyres, 138-145.
Semi-drop handle-bar, 154, 155.
Serrated foot-rest, 244.
Sextets, *see* Sextuplets.
Sextuplets, 32.
Shakespeare tandem, 27.
Sharp, A., cycle frames, 87.
Shaw, W. T., Boothroyd, J. W., and Sydenham, A., driving gear, 209.
variable driving mechanism, 208, 209.
built-up pneumatic tyres, 128, 129.
Sheet metal cycle frames, 87.
Silvertown pneumatic tyre, 129

Simonds, George F., results of experiments with ball bearings, 97, 98.
Simonds, J. S., and French, J. T., *see* Beeston Pneumatic Tyre Company Limited.
Simplex brake, 236.
Simpson, W. S., chain gearing, 177-180.
Singer detachable crank bearing, 166.
brake, 236.
Singer & Company Limited goods carrier, 50, 51.
modern improved "Velociman" tricyle, 57, 58.
ball steering and steering lock, 150-152.
Singer, G., cycle framework, 87.
and Granger, W., ball bearing, 94.
Single tube or hose-pipe pneumatic tyres, 121.
tube or hose-pipe pneumatic tyres, repairs to, 309, 310.
forks, liability of, to fracture, 159.
driving tricycles, 203, 205.
Sliding seats or saddles, 71.
angular vice, 249-250.
Small articles to nickel-plate, 274, 275.
hand - power spoke - drilling machine, 301.
hub-drilling machine, 256.
Smart's roller brake, 237.
Smith, W. B., cycle frames, 86.
Smith's flexible steel mandrel, 289.
built - up wire - fastened pneumatic tyre, 124.
Sociable tricycles, 46.
bicycles or dicycles, 32-34.
Socket tube, inner, repair of, 287.
ball head, to repair, 287, 288.
Solid metallic rims, 107.
rims or felloes, 16, 17, 107 112, 252-254.
rubber tyres, 116.
indiarubber tyres, repairs to, 308.
Solution, indiarubber, 309.
plating, 271.
stripping, 275, 276.
Spanners, adjustable, 244.
Sparkbrook detachable brake lug, 235, 236.
tricycle, 41, 42.
Sparkbrook Manufacturers' Company Limited roadster safety, 16-18.
band brake, 235.
racer, 22.
lady's safety, 25.
hollow metallic rim or felloe, 16, 17, 109, 110.
differential double tricycle axle, 207, 208.
Spaulding cycle, distinctive features of, 163, 164.
Special forks, 159.
Specification, Thomson's, 316-320.
Speedifier band, 139.
Spence, R. J. Peat, double rimmed or felloed wheel, 12.
Spence, *see* Hurrell and Spence.
Spherical toothed gearing, 182-192, 197-200.
Spinaway tricycles, 70.
Split cone nut pedal pin, 218.
Spokes, 112-115.
butted, to head, 296, 297.
wire, first invention of, 5.
wood, 113.
standard patterns of, 112.
direct, 112.
tangent or laced, 112-114.
replacing, 293-300.

Spokes, helical or undulating, 113.
tightening or screwing up, 260, 300, 301.
laced or tangent, securing at points of contact, 114, 115.
strain on, 115.
screwing machine, hand-power, 301.
grip and nipple key, 301.
holes for, drilling of, 253, 254.
Spoon brake, 233, 234.
Spring chain or sprocket wheel, 193.
cycle frames, 90-92.
plates or clips for tyres, 244.
wheels, 115.
tyres, 117-119.
handle-bars, 156.
Sprocket or chain wheels, 163-194, 203.
wheels, repairs to, 305-307.
Squeegee mud-guard, 244.
Stability of cycles, 61-78.
Standard tyre, 124.
"Star" safety bicycle, 9.
Starley detachable link chain, 162.
Starley, James, differential or balanced gear, 37, 204, 205.
Starley Brothers gentleman's tricycle, 39.
roadster safety, 14, 15.
lady's safety, 24, 25.
Statics, 62, 73, 74.
Steel driving bands, 194.
treatment of, for nickel-plating, 274.
Steering, the, 147-160.
heads, 147-153.
locks, 28, 29, 148, 150-153.
Step, cycle, 244.
Sterne & Company Limited emery band machine, 249.
emery grinder, 264.
Stevens' wood spokes, 113.
Stoney, F. G. M., on ball bearings, 94-96.
quadricycle, 5.
Stoney, G. J. and G. G., power consumed in driving, 72, 73.
Stoppers or plugs for fork ends, 158, 159.
Stove, gas-heated enamelling, 266.
Straight members, construction of cycle frames with, 289.
Strain on bicycle spokes, 115.
Strength of parts, 75, 76.
Strengthener, fork, 159.
tube, 248.
Strickland, V. H., *see* Morris, G. L.
Strickland's telescopic adjustable frame, 71.
Stripping and replating, 275, 276.
bath, 275, 276.
Stuart, Akroyd H., puncture-proof pneumatic tyre, 142, 143.
Sulphuric acid, *see* Solution Stripping.
Suspension wheel, first, 5.
Swing, adjusting bottom bracket, 173-175.
chain adjustment, 175, 176.
Swinging or adjustable handle-bar, 156.
Sydenham, A., *see* Shaw, W. T., Boothroyd, and Sydenham.

TANDEM bicycles, 27-31.
or triplet swing adjusting bottom bracket, 173-175.
tricycles, 43-46.
Tangent spokes, 113-115.
spokes, to replace, 113, 114, 229-301.
Tank, plating, 271, 276.
Tap, broken, to remove, 297, 298.

Tarnishing of nickel-plated surfaces, 277.
Taunton's patent mandrel, 289, 290.
Tayler, *see* Wallis-Tayler.
Tayler, D. F., & Company Limited, spokes, 112.
Taylor's tricycle, 56, 57.
Teeth, pivoting, 192.
Telescopic adjustable frame, 71.
Tension of wheel, to adjust, 260, 300.
"Terminus" pneumatic tyre, 124.
Terrell hydraulic brake, 237.
Tests on friction of ball bearings, results of, 98.
of helical tubes, 82-84.
Tetracycles, *see* Quadricycles.
Thomann & Buttner saddle, 228.
Thomson, R. W., first pneumatic tyre, 119.
Thomson's specification, 316-320.
Three-wheeled cycles, *see* Tricycles.
Tightening arrangement for saddle leathers, 232.
Toe-clip for rubber pedal, 223.
Toe-clips, 221-224.
Tool for heading butted spokes, 296, 297.
Townsend pedal pins, 218.
pedals, 218.
toe-clips, 221, 222.
T-piece, handle-bar, 288.
Traction on macadam roads, 77.
Transmission of power by ordinary block chain, 178, 179.
of power, Simpson chain, 178, 181.
Transparent gear cases, 243.
Treadle lathe, 303, 304.
Treatment of different metals for nickel-plating, 273-275.
Trent sand for polishing, 270.
Tricycle bottom bracket, 163.
Tricycle swing chain adjustment, 175, 176.
Tricycles, 30-46.
adjustment of, 176.
brakes for, 240.
classification of, 36, 37.
efficiency of, 68, 69.
single driving, 203, 204.
sociable, 46.
steering of, 147.
stability of, 37-39.
tandem, 43-46.
Triple head, 153.
Triplet swing adjusting bottom bracket, 173-175.
Triplets, 31.
Trouvé, A., cycle framework, 85.
Tube bending, 289-293.
clamp, 279.
damaged, removal of, 282, 284.
strengthener or ferrule, 248.
Tubes of large diameter, use of, in framework, 84.
most useful sizes for repair work, 288.
helical, 16, 81-84.
helical, strength of, 82-84.
steel, strength of, 75-81.
jointing, by hydraulic pressure, 85.
Tubeless pneumatic tyres, 133-138.
Tucker, H. C., unicycle or monocycle, 55.
Two sets of chain wheels and chain, employment of, 203.
Tyred, double, wheel, 21.
Tyres, 116-147.
compression of, 74.
spring plates or clips for, 244.
repairs to, 307-315.
inflators, 146, 147.
Tyton handles or grips, 158.

UNBREAKABLE forks, 159, 160.
toe-clip, 222.
Undulating or helical spokes, 113.
Unicycles, *see* Monocycles.
United States, use of system of hydraulic jointing in, 85.
Universal cycle jig, 250, 251.
Unpuncturable pneumatic tyres, 138-145.

VAJORK'S foot-motor boat, 56-60.
Valves, pneumatic, 120, 146, 147.
joints between, and air tube, leakage at, 315.
defective, leakage of, 315.
Variable speed gear, 200.
Varnish, coats of, in japanning, 269.
priming, 268.
Vat for plating, 271, 276.
Velociman tricycle, 56-58.
Velocipede Syndicate cam driving gear, 195.
Velocipedes, hand-power, 55-58.
ice, 58.
Verdot, E., & Cie. unbreakable fork, 159, 160.
Verdot, E. P., *see* Verdot, E., & Cie.
Vibration, 78.
Vice, angular sliding, 249, 250.
Victor toe-clip, 223.

WALKER, F. H., leather pneumatic tyre, 145, 146.
Wallis, J. *see* Otto, E. C.
Wallis-Tayler roller hub, 105, 106.
spring tyre, 117.
Warwick built-up, wire-fastened pneumatic tyre, 124.
Warwick, F. & E., plug for closing fork ends, 159.
hollow metallic rim or felloe, 108.
Warwick, John, goods carrier, 49, 50.
Water cycles, 58-60.
motor, 58-60.
Wear of balls in ball bearings, 96, 97.
Wedge-action built-up tyres, 125-133.
Wedging device grip pedals, 220, 221.
Weights of bicycles, comparative, 11.
distribution of, 73, 74.
Welch, C. K., built-up wire-attached pneumatic tyre, 121, 122.
Welch *v.* Caswell, judgment on, 123.
Welsh two-track bicycle, 36, 37.
Westwood hollow metallic rim or felloe, 108.
Westwood-Butler hollow metallic rim or felloe, 108.
Wheel, double tyred and rimmed, 21.
erector, factory, 260.
load in cycles, 12, 13, 63-68.
Wheels, 92-147, 157-260, 293-301, 307-320.
adjustment of, thrown out, 282, 283.
repairs to, 293-301.
Whippet spring cycle frame, 91.
White ground, enamel for, 269.
Whitworth, *see* Rudge-Whitworth.
Wilcox, Robert, on bicycle traction, 76, 77.
Wilson, W. T., *see* Morris, G. L.
Winton pedal, 224.
Wire-attached built-up pneumatic tyres, 121-125.

Wire, plated, dress guards, 244.
spokes, direct, 112.
spokes, first invention of, 5.
spokes, standard patterns of, 112.
spokes, tangent or laced, 112-114.
spokes, replacing, 293-300.
spokes, tightening or screwing up, 260, 300, 301.
Wood cycle frames, 87, 88.
handle-bar, 153.
japanning of, 267.
mud-guards, 244.
rims or felloes, 111, 112.
rim, to cement tyre to, 309, 310.
spokes, 113.
Woodley built-up pneumatic tyre, 124.
Work, repair, most useful sizes of tubes for, 288.
Wrenches, adjustable, 244.
Wright, *see* Morgan & Wright.
Wrought iron, to nickel-plate, 274.

"XTRAORDINARY" safety bicycle, 7.
wheel load of, 66.

ZENITH pneumatic tyre, 125.
Zimmy toe-clip, 223, 224.

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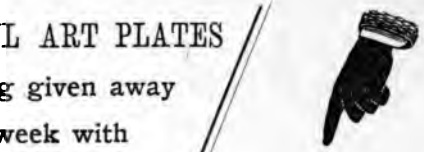

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